MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXXVIII. FEBRUARY 10, 1928. No. 4

ANNUAL GENERAL MEETING.

Rev. T. E. R. PHILLIPS, PRESIDENT, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The Report of the Auditors of the Treasurer's accounts for the year 1927 was read, and is given on p. 245.

The Annual Report of the Council was partly read.

The Address on the award of the Gold Medal was delivered by the President, after which the Gold Medal was handed to Professor R. A. Sampson, to whom it had been awarded for his Theory of the Four Great Satellites of Jupiter (see p. 334).

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 350.

The President then delivered short addresses on the awards of the Jackson-Gwilt Medal, after which the Jackson-Gwilt Medal and Gift were handed to Dr. W. H. Steavenson (to whom the Medal had been awarded for his work on faint variable stars and novæ, and on the

Herschel instruments), and to the Secretary for transmission to Mr. William Reid (to whom the Medal had been awarded for his discovery of six new comets) (see p. 344).

The following Amendments to the Bye-laws, which were proposed by the Council, and of which due notice had been given to the Fellows, were put to the Meeting and carried, with the exception of (*f*), bye-law 5 :—

(*a*) Bye-law 9. After the word " meeting," in line 5, insert the following words : " such list to contain the names of at least four Fellows not serving in any capacity on the existing Council."

(*b*) Bye-law 14. *For* " and there remain until the candidate is balloted for " *read* " and there remain until the election is decided."

Bye-law 15. *Substitute* " The election of candidates proposed as Fellows shall rest with the Council, subject to confirmation by the Fellows in Meeting assembled. Such election shall be decided at the second Ordinary Meeting of the Council after the reading of the recommendation as prescribed by the preceding bye-law."

Bye-law 16. *Substitute* " At the next Ordinary Meeting (the Annual General Meeting included) a list of the candidates so elected shall be read and put to the Meeting for confirmation, when, unless any Fellow demands a ballot, the election of all candidates in such list shall be deemed to be confirmed. If a ballot is demanded, it shall be taken at the close of the same Meeting, when each of the candidates shall be balloted for separately."

Bye-law 68. *For* " or that is to be balloted for " *read* " or whose election is for confirmation."

(*c*) Bye-law 14. *Delete* " or Associate."

Bye-law 29. *For* " The mode of proposing and balloting for " *read* " Save as provided in this section, the mode of proposing and electing."

(*d*) Bye-law 22. *For* " taken place in the month of February, March, April, May, or June ; but only one guinea as the first year's contribution, if such election has taken place in the month of October, November, December, or January), payable at the time of his election ; and two guineas for every subsequent year ; the first of such subsequent contributions to become due and be payable in advance on the 8th day of February then next following, and the succeeding ones, also in advance, on the 8th day of February in every subsequent year " *read* " taken place in the month of January, February, March, April, May, or June ; but only one guinea as the first year's contribution, if such election has taken place in the month of October, November, or December), payable at the time of his election ; and two guineas for every subsequent year ; the first of such subsequent contributions to become due and be payable in advance on the 1st day of January in every subsequent year."

Bye-law 65. *For* " due at the last Annual General Meeting " *read* " due on the 1st day of January of the preceding year."
Form 3. *For* " on the 8th day of February last " *read* " on the 1st day of January last."

(*e*) Bye-law 25. Line 1, *for* " two years " *read* " one year."
Bye-law 26. Line 1, *for* " two years " *read* " one year."
Line 7, *for* " three years " *read* " two years."
Line 10, *after* " Society " *insert* " (or in the case of Fellows resident abroad, at such later date as the Council shall determine)."

(*f*) Bye-law 5. Line 3, *for* " situation " *read* " position."
Bye-law 7. *Delete* " to appoint one of their own Members."
Bye-law 13. Line 6, *after* " Fellows " *add* " or Associates."
Bye-law 20. Line 4, *after* " Form No. 2 " *insert* " having been," *and for* " Member " *read* " Fellow."
Bye-law 24. Line 6, *for* " to " *read* " for."
Bye-law 66. Line 3, *for* " giving bond with two good and sufficient sureties " *read* " giving bond with good and sufficient surety."
Bye-law 80. *Substitute* " The Charter, the Common Seal, and the Deeds of the Society shall be placed in suitable iron boxes, or otherwise properly secured, so that in every case the same shall be under two different locks ; the key of one of which locks shall be kept by the President or other Fellow acting for him during his absence, and the key of the other by the Treasurer."

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Henry George Scott Barrett, Radcliffe Observatory, Oxford ;
D. G. A. Dyson, B.A., Kenwood, Loxley Lane, Stratford-on-Avon ;
Harold Jameson, B.Sc., Assistant Astronomer, Colombo Observatory, Ceylon ;
Bertram F. Jearey, c/o Divine Gates & Co., St. George's Street, Cape Town, S. Africa ;
Mohamed Abdur Rahman Khan, A.R.C.S., B.Sc., F.P.S.L., Principal of Osmania University College, Hyderabad, Deccan, India ;
Sydney Royston Pike, M.A., Physics Department, The University, Leeds ;
Sidney Herbert Pope, 31 Westbury Avenue, Wembley ;
Rev. John Pierce Price, North View, Dolcliffe Road, Mexborough, Yorks ;
R. O. Redman, B.A., Isaac Newton Student, St. John's College, Cambridge ;
John J. Richardson, Kurrawyba, Upper Spit Road, Mosman, N.S.W., Australia ;

William Henry Robinson, Radcliffe Observatory, Oxford ;
Abinas Chandra Sen-Gupta, A.C.S. Calcutta Port, 15 Strand Road, Calcutta, India ; and
Mario Rodriques de Sousa, Chief Assistant, Observatory, Rio de Janeiro,

were balloted for and elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Miss Ida Barney, A.B., Ph.D., Yale University Observatory, New Haven, Conn., U.S.A. (proposed by J. Jackson) ;
The Rev. Samuel Martin Johnstone, B.A., St. John's Rectory, Parramatta, N.S.W., Australia (proposed by U. L. Johnstone) ;
William Morton Page, C.B.E., M.A., H.M. Inspector, Board of Education, Norway House, Lostwithiel, Cornwall (proposed by W. M. Smart) ;
David B. Pickering, 171 South Burnett Street, East Orange, New Jersey, U.S.A. (proposed by G. Merton) ; and
Ernest Tillotson, B.Sc., 23 Roseville Road, Leeds (proposed by R. Stoneley).

Report of the Council to the Hundred and Eighth Annual General Meeting of the Society.

Progress and Present State of the Society.

	Patron	Institutional Members	Honorary Member	Fellows		Associates	Total
				Compounders	Annual Subscribers		
1926 December 31	1	2	1	225	667	48	944
Since elected	...	...	...	+1	+59	+2	...
Deceased	...	...	...	−6	−12	−2	...
Resigned	...	...	...	...	− 7	...	...
Since compounded	...	...	...	+2	− 2	...	...
Removed from list	...	...	...	...	− 7	...	...
1927 December 31	1	2	1	222	698	48	972

(Five Associates are also Fellows, and are therefore counted twice in the above table.)

RECEIVED.

	£ s. d.	£ s. d.
Received on account of Dividends:—		
£1,250 Metropolitan 3-per-cent. Stock (Tax free) ...	37 10 0	
£2,000 Swansea Corporation 3½-per-cent. Stock (Tax free)	70 0 0	
£2,287, 6s. 9d. East Indian Railway 3-per-cent. Debenture Stock	54 17 10	
£5,125 London, Midland and Scottish Railway 4-per-cent. Debenture Stock	164 0 0	
£750 London, Midland and Scottish Railway 4-per-cent. Consolidated Preference Stock	24 0 0	
£2,400 Gas Light & Coke Co. 3-per-cent. Debenture Stock	57 12 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	48 0 0	
£3,852, 12s. 6d. War Loan Inscribed 5-per-cent. Stock (Tax free)	192 12 6	
Interest on Deposit Account	10 7 4	
Income Tax on 1925–1926 Dividends refunded £98 13 0		
Less allotted to Special Fund and Trust Funds... ... ... 3 14 2		
	94 18 10	
		753 18 6
Sale of Publications:—		
Monthly Notices, Memoirs, Geoph. Suppl., etc.:—		
At Society's Rooms £17 7 1		
At Wheldon & Wesley's 268 19 5		
	286 6 6	
Slide Catalogue	1 12 0	
Reprints	103 5 4	
		391 3 10
Sale of Photographs (including *Higgs' Spectra*)	... ...	156 4 10
Miscellaneous Receipts:—		
Postages, etc., repaid	9 10 0	
London Mathematical Society, expenses of Meetings, etc.	30 0 0	
Use of Telephone	0 2 11	
Assistant Secretary and Clerk, Pension Premiums ...	19 5 0	
		58 17 11
		1360 5 1
Trust Fund Dividends:—		
£1,212, 13s. 3d. East Indian Railway 3-per-cent. Debenture Stock	29 2 2	
£542, 18s. 2d. India 3½-per-cent. Stock (Tax free) ...	19 0 0	
£1,934, 10s. 2d. 5-per-cent. War Stock, 1927/47 (Tax free)	96 14 6	
Income Tax (1926 January to March) refunded ...	1 16 5	
		146 13 1
Special Fund:—		
Donations in 1927	55 0 0	
Interest on National War Bonds	50 0 0	
Dividends, £419, 17s. 11d. Conversion Loan 4½-per-cent. Stock	15 2 4	
Income Tax on ditto (1926 Half-year) refunded ...	1 17 9	
		122 0 1
Redemption of National War Bond, 1927 (Special Fund)		525 0 0
Received on account of Subscriptions:—		
540½ Annual Contributions for 1927 (including 2 Institutional Membership fees)	1135 1 0	
8½ Annual Contributions for 1928, paid in advance ...	17 17 0	
56 Admission Fees (including 3 due in 1926)	117 12 0	
55 First Contributions (including 3 due in 1926) ...	95 11 0	
Arrears paid off:—		
1 for 1922 ... ... £2 2 0		
1 for 1923 ... ... 2 2 0		
10¾ for 1924 ... ... 22 12 0		
24 for 1925 ... ... 50 8 0		
48 for 1926 (less 2s.) 100 14 0		
	177 18 0	
		1543 19 0
Compositions		57 15 0
Balances, 1927 January 1:—		
In hand of Assistant Secretary on Petty Cash Account	19 5 8	
At Bankers', on Current Account, as per Pass Book ...	294 14 5	
At Bankers', on Deposit Account (including Special Fund, £93, 12s. 4d.)	391 3 0	
At Bankers', on "C" Account (Trust Funds) ...	134 16 0	
		839 19 1

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	225	0	0			
Clerk: Salary	160	0	0			
Assistant Secretary and Clerk for work for London Mathematical Society in 1926	10	0	0			
Pension Premiums for Assistant Secretary and Clerk ...	57	15	0			
Porter and Wife: Wages	147	0	0			
Health and Unemployment Insurance	6	8	6			
Pensions, J. and Mrs. Barrett	78	0	0			
				684	3	6
Licence for Porter	0	15	0			
Fire and Accident Insurance	15	15	3			
Telephone	12	7	5			
Registration of Telegraphic Address	2	0	0			
Time Signal	5	2	8			
				36	0	4
Postage and Packing (including postage of *Monthly Notices*, etc., £98, 12s. 3d.)				143	7	3
Printing, etc.:—						
Monthly Notices (Vol. 87, Nos. 1–9)	924	14	11			
Geophysical Supplements (Nos. 8 and 9)	116	15	5			
Memoirs (Vol. 64, pts. 3, 4, and Appendix)	239	9	5			
Reprints	112	17	2			
Miscellaneous	85	2	6			
Photo-engraving	122	12	9			
				1601	12	2
Reproduction of Photographs for sale				126	14	2
Library Equipment and Binding	80	2	2			
Stationery and Office Expenses	25	2	4			
Coal, Gas, Electric Light, Firewood	89	6	5			
House Cleaning and Laundry	19	14	5			
Repair of Cœlostats	84	17	6			
Fittings and Repairs	35	14	7			
Miscellaneous Expenditure	10	3	4			
Expenses of R.A.S. Meetings	18	4	1			
Expenses of Geophysical Discussions	6	0	5			
Expenses of L.M.S. Meetings	5	18	9			
Subscription to International Telegrams Bureau (1927, 1928)	9	13	9			
Purchase of scarce numbers of *Monthly Notices*	0	12	6			
				385	10	3
Bank Charges and 2 Cheque-Books				2	0	5
				2979	8	1
Purchase of £695, 16s. 3½-per-cent. Conversion Loan, 1961 (Special Fund)				525	0	0
Expenditure on Trust Accounts:—						
George Darwin Lecture	49	8	2			
Turnor and Horrocks Fund } Library	13	6	1			
Harry Watson Fund ... }	60	2	10			
Lee and Janson Fund	10	0	0			
				132	17	1
Balances, 1927 December 31:—						
In hand of Assistant Secretary on Petty Cash Account	34	15	9			
At Bankers', on Current Account, as per Pass Book	383	15	5			
At Bankers', on Deposit Account (including Special Fund, £215, 12s. 5d.)	391	3	0			
At Bankers', on "C" Account (Trust Funds) ...	148	12	0			
				958	6	2
				£4595	11	4

Examined and found correct.

(Signed) P. J. Melotte.
C. O. Bartrum.

REVENUE

	£	*s.*	*d.*	£	*s.*	*d.*
To General Expenditure as per Cash Account	2979	8	1			
,, Reserve for Accounts due but not presented	240	0	0			
	3219	8	1			
Less Reserve for Accounts due 1926 now written back	218	0	0			
				3001	8	1
,, 22 Annual Contributions in Arrear written off ...	46	4	0			
Less 4 ditto written off in 1925 and now paid ...	8	8	0			
	37	16	0			
,, 1 Admission Fee and First Contribution 1926 written off (election void)	3	3	0			
,, 8 Annual Contributions 1927 written off as per contra	16	16	0			
				57	15	0
,, Due for Publications, 1924, but unpaid, and now written off	...		...	1	10	0
,, Income Tax attributable to Special Fund included in item of £90, 18s. credited to Revenue Account 1926, written back				3	15	6
				£3064	8	7

Examined and found correct.

(Signed) P. J. MELOTTE.
C. O. BARTRUM.

1928 *January* 9.

ACCOUNT, 1927.

		£ s. d.	£ s. d.
By Subscriptions—			
540½	Annual Contributions for 1927 (including 3 from Fellows elected 1927 January, and 2 Institutional Membership Fees)	1135 1 0	
9½	ditto, paid in advance in 1926, and now matured	19 19 0	
104	ditto, outstanding	218 8 0	
8	Contributions for 1927 due, but unpaid, in respect of Fellows died. or names removed, and written off per contra	16 16 0	
662			1390 4 0
,, 36	First Contributions, 1927, at 2 guineas ...	75 12 0	
16	ditto, at 1 guinea	16 16 0	
7	ditto, outstanding	7 7 0	
59			99 15 0
,, 53	Admission Fees, 1927	111 6 0	
7	ditto, outstanding	14 14 0	
60			126 0 0
,, 1	Composition Fee (initial)	31 10 0	
2	ditto (reduced)	26 5 0	
3			57 15 0
,, Sundry Debtors, 1927		... ...	42 6 2
,, Dividends, Sales of Publications and Photographs, and Miscellaneous Receipts, as per Cash Account		1360 5 1	
Less	Payments due in 1922-26 (£59, 6s., *less* £1, 10s. written off, and £5, 3s. still outstanding) ... £52 13 0		
	Income Tax 1925 April to December refunded 60 16 3		
	Ditto, 1926 January to April (£37, 16s 9d., *less* £1, 17s. 9d. allotted to Special Fund and £1, 16s. 5d. to Trust Funds) ... 34 2 7		
		147 11 10	1212 13 3
By Income Tax (General Fund only) deducted—			
	1927 January to April	34 2 7	
	1927 April to December	52 19 11	
			87 2 6
Excess of Expenditure over Income, 1927		... ...	48 12 8
			£3064 8 7

BALANCE SHEET,

LIABILITIES.

	£ s. d.	£ s. d.
8½ Subscriptions 1928, paid in 1927		17 17 0
Sundry Creditors for Accounts due but not presented ...		240 0 0
Cash Balances (Income) due to Trust Funds—		
Turnor and Horrocks Fund	2 5 0	
Harry Watson Fund	28 13 6	
Lee and Janson Fund	24 14 2	
Hannah Jackson Fund	68 5 3	
George Darwin Lectureship Fund	24 14 1	
		148 12 0
Trust Funds (Capital), as per contra		2,949 17 0
Special Fund—		
As at 1926 December 31	1,566 8 9	
Donations and Interest, 1927	122 0 1	
	1688 8 10	
Deduct Depreciation on Conversion of War Bond ...	16 11 2	
		1,671 17 8
Income Tax 1926, 1927, not yet received, attributable as per contra—		
To Special Fund...		5 13 3
To Trust Funds		12 14 7
General Fund—As at 1926 December 31	15,921 17 0	
Deduct—Excess of Expenditure over Income, 1927	48 12 8	
		15,873 4 4
		£20,919 15 10

222 Compounders.

Examined and found correct.

(Signed) P. J. MELOTTE.

C. O. BARTRUM.

1928 *January* 9

1927 *December* 31.

ASSETS.

	£ s. d.	£ s. d.
Sundry Debtors for Subscriptions in Arrears—		
½ for 1924	1 1 0	
14 for 1925	29 8 0	
44 for 1926 (plus 2s.)	92 10 0	
104 for 1927	218 8 0	
7 First Contributions for 1927, outstanding ...	7 7 0	
7 Admission Fees for 1927, outstanding	14 14 0	
		363 8 0
Sundry Debtors, 1922-1926		5 3 0
Sundry Debtors, 1927—		
Due for Publications and Reprints	3 17 11	
Due from Wheldon & Wesley for Publications sold during the last quarter of 1927	33 3 8	
Due for Photographs	4 13 0	
Due for Postages and Packing	0 11 7	
		42 6 2
Investments, General Fund, valued as on 1922 December 29		14,986 0 0
Investments of Special Fund, valued as at date of purchase—		
£500 National War Bond 1929	531 5 3	
£695 16s. Conversion Loan 3½% 1961	525 0 0	
£419 17s. 11d. Conversion Loan 4½% 1940-44 ...	400 0 0	
		1,456 5 3
Investments of Trust Funds (including George Darwin Lectureship Fund) valued as on 1922 December 29 or date of purchase if later		2,949 17 0
Income Tax 1926 April-December, not yet refunded—		
General Fund £52 19 11		
Special Fund 1 17 9		
Trust Funds 5 9 1		
	60 6 9	
Ditto, 1927 January-December, outstanding—		
General Fund 87 2 6		
Special Fund 3 15 6		
Trust Funds 7 5 6		
	98 3 6	
		158 10 3
Sundry Balances—		
Cash at Bank on Current Account	383 15 5	
,, ,, Deposit (including Special Fund, £215, 12s. 5d.)	391 3 0	
,, ,, "C" Account (Trust Funds) ...	148 12 0	
Cash in hand of Assistant Secretary	34 15 9	
		958 6 2
		£20,919 15 10

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

Three Gold Medals.

One Bronze (Jackson-Gwilt) Medal.

INVESTMENTS.

As at 1927 December 31.

GENERAL FUND.

£1250 Metropolitan 3-per-cent. Stock.

£2000 Swansea Corporation 3½-per-cent. Stock.

£2287, 6s. 9d. East Indian Railway 3-per-cent. Debenture Stock.*

£5125 London, Midland, and Scottish Railway 4-per-cent. Debenture Stock.*

£750 London, Midland, and Scottish Railway 4-per cent. Consolidated Preference Stock.*

£2400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.*

£2000 Commercial Gas Co. 3-per-cent. Debenture Stock.*

£3852, 12s. 6d. 5-per-cent. War Loan Inscribed Stock, 1929–47.

GROVE-HILLS SPECIAL FUND.

£500 National War Bonds, 1929.

£695, 16s. Conversion Loan 3½-per-cent., 1961.*

£419, 17s. 11d. Conversion Loan 4½-per-cent.*

FIVE TRUST FUNDS.

£1212, 13s. 3d. East Indian Railway 3-per-cent. Stock.*

£542, 18s. 2d. India 3½-per-cent. Stock.

£1934, 10s. 2d. 5-per-cent. War Loan Inscribed Stock, 1929–47.

* Taxed at source.

Report of the Auditors for the Year 1927.

We have examined the Treasurer's account of receipts and expenditure, and the Revenue Account and Balance Sheet, for the calendar year 1927, and have certified these accounts to be correct.

The investment holdings have been certified by the Bank of England and the Westminster Bank respectively.

The Revenue Account for the year shows a deficiency of income over expenditure of about £49 after three years of increasing excess. This is in spite of a growing revenue from annual contributions and admission fees due to the steady addition to the number of Fellows, and a continued increase of the proceeds of sales of publications, etc. This deficiency is partly to be attributed to the increased expenditure on printing, especially of memoirs, and to the item for the repair of cœlostats. A contributory cause of the less favourable appearance of this account is the decrease in receipt of composition fees. These are treated each year as revenue, though they are of the nature of capital receipts with a wasting liability. Under a strict method of finance they would be added to the invested funds of the Society or put to a special reserve.

£500 National War Bonds of the Grove-Hills Special Fund matured during the year and were paid off. The proceeds were re-invested in £695, 16*s.* three and a half per cent. Conversion Loan.

The total invested funds, valued at 1927 December 30, amount to £19,485, a figure higher by £93 than that at which they stand on the Balance Sheet. At this valuation they yield 4·9 per cent. in gross dividends (before deduction of income tax).

The donations to the Special Fund include one of £50 generously contributed by Dr. Harold Jeffreys.

A list has been placed on the table of the names of those Fellows who are in arrear for sums that were due at the date of the last Annual General Meeting, with the amount due against each Fellow's name.

The books, instruments, and other effects appear to be in satisfactory order. The books on the shelves of the library are in course of being carefully checked with the entries on the card catalogue.

We have received from the Assistant Secretary all the information and explanations we have required in the elucidation and certification of the Accounts.

(Signed) P. J. Melotte.
C. O. Bartrum.

1928 *January* 23.

Gifts to the General Funds of the Society.

The John Lee Gift: In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The Knott Gift (1899): Mrs. George Knott presented to the Society the sum of £250, to defray the cost of printing *Memoirs*, vol. lii., containing the late Mr. Knott's Observations of Variable Stars.

The Peek Bequest (1904): Sir C. E. Peek bequeathed to the Society the sum of £200, as a contribution towards the expense of printing the Rousdon Variable Star Observations (*Memoirs*, vol. lv., part 1).

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Brook Gift (1907): C. L. Brook, Esq., gave one-third of the cost of printing Pogson's Variable Star Observations (*Memoirs*, vol. lviii.).

The Gill Bequest (1914): Sir David Gill, K.C.B., F.R.S., bequeathed to the Society the sum of £250, in aid of Astronomical Research, in grateful remembrance of a like sum paid out of the funds of the Society in aid of his expedition to Ascension in the year 1877. In accordance with his wishes this bequest was expended to defray part of the cost of publishing vol. lxiii. of the *Memoirs*, containing the Theory of the Four Great Satellites of Jupiter.

The Parsons Gift (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock (1929–47), in memory of his father, the 3rd Earl of Rosse, who made the 6-foot Reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early Astronomical and Mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Grove-Hills Special Fund: In 1923 the then Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. He aimed at securing £1800, and up to the present the total amount received from all sources (including dividends on the investments representing the fund) is £1888, 8*s.* 10*d.*, of which £200 was transferred during 1923 to the General Fund to meet current expenditure, and £1472, 16*s.* 5*d.* was invested, and is now represented by £500 National War Bond 1929, £419, 17*s.* 11*d.* Conversion Loan 4½ per cent. 1940–44, and £695, 16*s.* Conversion Loan 3½ per cent. 1961.

	£	*s.*	*d.*		£	*s.*	*d.*
1927 Jan. 1. Cash Balance of Fund	93	12	4	1927 Nov. 21. Purchase of £695, 16*s.* Conversion Loan 3½ per cent. 1961	525	0	0
Donations in 1927 ..	55	0	0	1927 Dec. 31. Cash Balance of Fund on Deposit	215	12	5
Interest on National War Bonds and Conversion Loan ..	65	2	4				
Income tax 1926 Jan.–March refunded ..	1	17	9				
Redemption of £500 National War Bond 1927	525	0	0				
	£740	12	5		£740	12	5

The following were donors to this Fund in 1927 :—

H. Jeffreys. R. Stretton Webb.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1927 Jan. 1. Balance of Fund	26	3	8	1927. Grant from Fund ..	10	0	0
1927. Dividends, East Indian Railway ..	8	0	6	1927 Dec. 31. Balance of Fund	24	14	2
Income tax 1926 Jan.–March refunded		10	0				
	£34	14	2		£34	14	2

The Turnor Fund and the Horrocks Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in

Westminster Abbey to Jeremiah Horrocks : to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1927 Jan. 1. Balance of Fund	1	1	2	1927. Purchase of Books	13	6	1
1927. Dividends, East Indian Railway ..	13	12	10	1927 Dec. 31. Balance of Fund	2	5	0
Income tax 1926 Jan.–March refunded		17	1				
	£15	11	1		£15	11	1

The Harry Watson Memorial Fund : In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the Library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s.* 0*d.* to the Society, which now stands invested in £946, 6*s.* 11*d.* 5-per-cent. War Stock 1929–47. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

	£	*s.*	*d.*		£	*s.*	*d.*
1927 Jan. 1. Balance of Fund	22	10	0	1927. Purchase of Books ..	25	9	10
1927. Dividends, India 3½ per cent.	19	0	0	Binding	34	13	0
Dividends, War Stock 5 per cent.	47	6	4	1927 Dec. 31. Balance of Fund	28	13	6
	£88	16	4		£88	16	4

The Hannah Jackson (née Gwilt) Fund : In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1927. Jan. 1. Balance of Fund	60	7	1	1927 Dec. 31. Balance of Fund	68	5	3
1927. Dividends, East Indian Railway ..	7	8	10				
Income tax 1926 Jan.–March refunded		9	4				
	£68	5	3		£68	5	3

The George Darwin Lectureship Fund : In 1926 June, the then President, J. H. Jeans, Esq., D.Sc., Sec. R.S., presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be

called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum has been invested in £988, 3*s.* 3*d.* 5-per-cent. War Stock 1929–47, and the income will be annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

	£	*s.*	*d.*		£	*s.*	*d.*
1927 Jan. 1. Balance of Fund	24	14	1	1927 March 14. Lecture-ship Fee	49	8	2
1927 Dec. 1. Dividends, War Stock 5 per cent.	49	8	2	1927 Dec. 31. Balance of Fund	24	14	1
	£74	2	3		£74	2	3

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.

391. Track of Solar Eclipse across England, 1927 June 29. [*Slide only.*]
392. Solar Corona, 1927 June 29, Giggleswick, 6-in Refr., F.L. 45 ft., Exp. 19 secs., Royal Observatory, Greenwich.
393. Solar Corona, 1927 June 29, Jokkmokk, 11-m. Refl., Ap. 35 cm., Exp. 1 sec., Hamburg Observatory Expedition.
394. Solar Corona, 1927 June 29, Jokkmokk, Refr., Ap. 10 cm., F.L. 3·65 m., Exp. 25 secs., Hamburg Observatory Expedition.

Publications of the Society.

During the past year the Society has published *Monthly Notices*, vol. lxxxvii., *Geophysical Supplement*, No. 9, and *Memoirs*, vol. **64**, pts. 3, 4, and Appendix.

Memoirs, Vol. 64, pt. 3. G. Merton, The Periodic Comet Grigg (1902 II)—Skjellerup (1922 I), (1902 to 1927).
Vol. 64, pt. 4. C. R. Davidson and F. J. M. Stratton, Report on the Total Solar Eclipse of 1926 January 14.
Vol. 64, Appendix. Drawings of the Corona from Photographs at Total Eclipses from 1896 to 1922.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—Alexander Williams Anderson.
Thomas Dalby Brewin.
Daniel Buckney.
George Calver.
Henry Ellis.
Henry Bedingfield Goodwin.
Thomas Hands.
Edward Rupert Hicks.
* John Hixon Irving.
John Rudd Leeson.
Thomas Lewis.
Louis George Macrory.
William Cunliffe Margerison.
William Francis Rigge.
William Smith.
John Tatlock.
Antonio Vela-Herranz.
Associates :—† Carl Hermann Gustav Müller.
Jens Frederik Wilhelm Schroeter.

Commander Alexander Williams Anderson, R.N.R., of the P. & O. Company, died at Wiesbaden in September last, aged sixty-six. He commanded the troopship "Plassy" during the South African War, and during the Great War he acted as harbour-master at Calais. For the last three years of his life he had been serving with the British Army on the Rhine.

He was elected a Fellow of the Society on 1926 February 12.

Thomas Dalby Brewin was born on 1840 May 19 in Leicester, where he carried on for many years the business of a watchmaker. One of the best public clocks in Leicester, that of St. George's Church, was made entirely by him. He was a skilful craftsman of the old-fashioned type, who could work wonders with quite a simple lathe. He mounted quite a number of telescopes for various amateurs, including refractors up to 5-inch and specula as large as 11-inch, and his work was always reliable. He was a keen astronomer, and made very creditable sketches of the planets, especially of Mars, which was his favourite, his telescope being a 4-inch Wray. A paper by him on the "Rotation Period of Jupiter" appeared in *Monthly Notices*,

* Died 1926, death not notified till 1927.

† Died 1925. The Council much regrets the omission of Dr. Müller's name from the Obituary List of that year.

40, 377. After the death of his wife in 1914 he retired from business and moved to the suburbs of Leicester, where he had a better position for his telescope; but his health began to decline, and he went to live with his sister-in-law at Lutterworth, where he passed peacefully away on 1927 January 14 at the age of eighty-six. He was of a kindly nature, and endeared himself to all who came into contact with him.

He was elected a Fellow of the Society on 1877 June 8.

Daniel Buckney was born in 1845 at Bankside. He was a brother of Thomas Buckney, who in 1871 constructed the Sidereal Standard Clock for the Royal Observatory, Greenwich, and arranged for the hourly time-signal from Messrs. Dent & Co. to the Society's rooms. After being apprenticed to David Keys, Daniel Buckney started business as a watch and chronometer maker in Southampton Row, later on moving to King's Square where he worked for twenty-six years. In 1908 he transferred his business to Old Broad Street, and handed it over to his eldest son in 1920 on his return from military service. Mr. Buckney took a keen interest in horological matters, especially on the educational side. He was elected to the Council of the British Horological Institute in 1884 and was Vice-President from 1888 to 1903. He was also Treasurer of the Watch and Clockmakers' Benevolent Institute from 1891 to 1912, and was on the Court of the Clockmakers' Company. Latterly Mr. Buckney was Managing Director of Messrs. E. Dent & Co. Throughout his career he stood for the highest quality of workmanship, and was awarded diplomas of honour and prize medals for his watches in London and Melbourne. He died on 1927 July 27 at his residence, Highfield, Cedar Road, Sutton.

He was elected a Fellow of the Society on 1904 May 13.

George Calver was born at Yarmouth on 1834 July 22, but later made his home at Chelmsford until, in 1904, he moved to Walpole in Suffolk, where he lived until his death at the age of ninety-two. Quite early in his life he started making astronomical observations with a 10-inch reflecting telescope, of which he made the mirror while still living at Yarmouth, but it was as a maker of mirrors that he was to become famous. Dr. A. A. Common was a friend who early recognised his capabilities, and Mr. Calver made for him in 1876 the 18-inch mirror for his second telescope. A few years later he made for him a 37-inch mirror, and it was with this mirror that Common took the photographs for which he received the Gold Medal of the Society in 1884. This mirror, with the mounting, was subsequently sold to Mr. Edward Crossley, who, after using it himself for some years, presented it to the Lick Observatory, where in the hands of Keeler it did such fine work on the nebulæ.

Other large mirrors by Mr. Calver include one of 50 inches made for Sir Henry Bessemer which was not a success; there is, however, reason to believe that in the construction of this mirror Mr. Calver had not a free hand, Sir Henry Bessemer having ideas of his own which he wished to see carried into effect. He also made a 30-inch mirror

for Mr. D'Esterre in 1914 which was never mounted ; he had previously made a 15-inch for the same observer, who utilised it to obtain most beautiful photographs of Milky Way regions. The 20-inch mirrors of Mr. J. H. Worthington and Mr. Henry Ellis were also made by Mr. Calver. In 1919 he refigured the 24-inch mirror of the Royal Observatory, Edinburgh. The total number of his mirrors must have been very large, for he worked assiduously, often to the detriment of his health.

Mr. Calver published in 1894 a book entitled *Hints on the Silvered Glass Telescopes*, and wrote a number of articles on the making and testing of mirrors, including one in the *Monthly Notices* for 1879 describing in detail the making of the 37-inch mirror for Dr. Common.

As would be expected of one who took a pride in carrying his work to such a high degree of perfection, Mr. Calver was a man of artistic temperament and a great lover of music ; while living at Chelmsford he was a member of the local musical society. He died at Walpole in 1927 July, leaving a widow.

He was elected a Fellow of the Society on 1877 June 8.

Henry Ellis was born on 1858 April 14. He was the grandson of William Ellis, who was very well known in the City of London as underwriter to, and later as Director of, the Mutual Marine Assurance Company, and as an authority on education and founder of the William Ellis Schools. Henry Ellis's father, Edward Ellis, died when his son was only seven years old ; and after attending schools at Manchester and Elstree, Henry Ellis, at the age of sixteen, entered the office of the Indemnity Mutual Marine Assurance Company, where he worked for over thirty years, retiring in 1909.

He joined the Bloomsbury Rifles in 1877, attaining the rank of captain. He was also very fond of music, playing the violoncello ; and a feature of his home life at Potters Bar, where he lived for many years, was the playing of quartets with his three daughters. After his retirement to Lyme Regis he played in the Operatic Society Orchestra.

In 1883 Henry Ellis married Margaret Morley, second daughter of the late Professor Henry Morley of University College. He had two sons, both of whom gave their lives in the Great War, and three daughters, who, with his wife, survive him.

At an early age he took a great interest in scientific pursuits of all kinds, and later devoted himself especially to astronomy. While at Potters Bar, he acquired a 20-inch reflecting telescope by Grubb, for which he built an observatory. In 1913 he removed the equipment to Lyme Regis, where he had built a house on retirement. He devoted himself mainly to the photography of nebulæ, and contributed numerous papers to the British Astronomical Association, of which he was an early member. These papers include notes on photographs of Nova Persei, Changes in Nebulæ, the Orion Nebula, photographs of Clusters and of Comet 1908*c*, and many others. From 1913 to 1921 and again from 1923 till his death he was treasurer of the British Astronomical Association, and was engaged on the duties of that office till within a few days of his death on 1927 September 6.

After his retirement to Lyme Regis, Henry Ellis took an active part in the affairs of that town, being elected a Town Councillor in 1919 and Mayor during the three years 1921–24.

He was elected a Fellow of the Society on 1898 June 10.

A. E. L.

Henry Bedingfield Goodwin, after graduating at Cambridge in 1868, joined the staff of the Royal Naval College, Portsmouth. Later he became an instructor in the Royal Navy, and subsequently was Examiner in Nautical Astronomy at the Royal Naval College, Greenwich, and to H.M. Board of Education. He was the author of a textbook on trigonometry and of several works on navigational astronomy, in which subject he had a world-wide reputation. For some time he was assistant editor of *Brown's Nautical Almanac*, and was a frequent contributor to the *Nautical Magazine*. He died at Norbury on 1927 February 24 at the age of seventy-nine.

He was elected a Fellow of the Society on 1919 February 14.

Edward Rupert Hicks, son of E. S. Hicks, wharfinger, and descended on his mother's side from James Brindley, the famous engineer, was born in London in 1845. He was one of the oldest wharfingers in London, the wharf having been in the family for over a hundred years. He was educated in Hanwell, and at an early age succeeded to the family business, which absorbed most of his time. In spite of the claims of business, however, his real life interest was always in astronomy. He took a keen interest in comets, more especially those that have made fairly close approaches to the earth in recent years, such as Halley's in 1910 and Pons-Winnecke in 1921 and 1927. He studied the circumstances of these approaches, and made ingenious models of jointed cardboard, which represented the conditions with sufficient accuracy for illustrative purposes. He made similar models of eclipses of the sun and moon, showing the progress of their phases at different stations. Some of these models were exhibited at the Brussels Exhibition of 1910; they were very serviceable for educational purposes. In later years he took up Egyptology, and was interested in the Pyramids from the point of view of one who tries to connect their measurements with biblical prophecies. He made computations of the dates when different stars would have shone down the northern passage at lower culmination.

In 1888 Mr. Hicks married Mrs. Bohun-Brown, née Mouat. He lived in London all his life, and was a familiar figure at the Society's rooms, rarely missing a meeting. He died at his residence, 67 Holland Road, Kensington, on 1927 November 27, leaving a widow and one stepdaughter, Miss Aimée de Bohun.

He was elected a Fellow of the Society on 1910 February 11.

Dr John Rudd Leeson was the only son of John Leeson, of Berkeley Square, London, W., where he was born. He received his medical education at the Universities of London, Edinburgh, Vienna, and Berlin, and in the seventies, while at Edinburgh, was a pupil of

Lister, whose coveted Gold Medal for Clinical Surgery he gained, and who offered him the post of house-surgeon. Last year Dr. Leeson published his reminiscences in a book entitled *Lister as I knew Him*, which has been received with widespread appreciation.

After thirty years of general practice at Twickenham, in which he achieved striking success, he retired at the age of fifty-four in order to devote himself to science and to philanthropic work for his adopted town of Twickenham, and here he laboured for the remaining nineteen years of his life, sitting on the Middlesex County Council, becoming a County Magistrate, Chairman of the local Hospital, Philanthropic Society, Charity Trustees, Twickenham Literary and Scientific Society, Education Committee, and President of the S.W. Middlesex Boy Scouts Association. In 1926 he succeeded in obtaining a Charter of Incorporation for the town, becoming its Charter Mayor and First Mayor, during which term of office he passed away. Charter Day in Twickenham was observed with great splendour and rejoicing, finding its focus in his inspiring and beloved personality, for he had veritably become the father of the place, giving his unsparing help to people of every class and creed in every type of difficulty.

His leisure time during all these years he devoted largely to astronomy and to the study of pond life. He possessed a telescope by Cooke with which he spent many a wonderful night; he was also a skilled microscopist and had a biological laboratory at his home. He was a member and one of the visitors of the Royal Institution and on the Court of the Salters' Company.

Dr. Leeson died on 1927 October 23 at the age of seventy-three.

At his funeral the whole town turned out to mourn him, for the jovial and inspiring personality of the Mayor, united with that of the untiring friend and beloved physician of former years, had endeared him deeply to all classes and callings of men. His coffin was covered with the white flag of the new borough, and the "Last Post" was sounded at his graveside by Volunteer fellow-townsmen.

His only son, Mr. Spencer Leeson, formerly sixth-form master at Winchester, is the present Headmaster of the Merchant Taylors' School.

He was elected a Fellow of the Society on 1911 December 8.

Thomas Lewis, who may be known to the majority of the present Fellows only through the indexes of the *Monthly Notices* and by his splendid volume on the Struve double stars, was at one time a well-known figure at the meetings, and twenty years ago occupied the Secretarial chair.

Lewis was on the staff of the Royal Observatory, Greenwich, which he joined early in the year 1881, and represented two apparently incongruous branches of work of the establishment, chronometer rating and double-star observing. When he joined, he was given the task of superintending the reduction of the zenith distance observations made with the Transit-Circle, but at the end of the year when there was a rearrangement of staff consequent on the retirement of Airy from the position of Astronomer Royal, at his own wish he was made Superintendent of the Time Department and occupied that office until his retirement

in 1917. This carried with it the work connected with the storing, rating, repairing, and issuing of chronometers. This work grew to large dimensions during the thirty-five years of his guardianship, for in 1881 there was one chronometer room only at Greenwich, but in 1917 there were three, and a room devoted to apparatus for reception of radio time-signals was also in Lewis's charge at the latter date. The growth of the chronometer department added much to his responsibility, which was recognised by his promotion, slightly out of turn, to fill a First-class Assistantship specially created by the Admiralty at the end of the year 1891.

As to his observing, in the first twelve years of his service at Greenwich Lewis took turn with others in the routine with the Transit-Circle, Altazimuth, and small Equatorial, and being a careful observer was chosen to be the colleague of Mr. (now Professor) H. H. Turner in the determination of the longitude Paris-Greenwich in 1888. When the staff was increased in number in the year 1892 he was relieved from Transit-Circle observing in order that he might devote his efforts to the micrometric observation of double stars, which he had chosen as a special line of work for himself, and in which he had already shown his interest by his paper on the "Orbit of 36 Andromedæ" in the *Monthly Notices* for 1891 June. His first published observations were made with the Merz $12\frac{3}{4}$-inch telescope, formerly the Great Equatorial at Greenwich, which, when it was dismounted to make way for the 28-inch refractor, was at his instigation placed in 1892 May on the mounting of the Lassell reflector, then housed in a low building in the south ground of the Observatory. With this instrument he worked single-handed during the year 1893, the result being a communication to the Society in 1894 March of a list of measures of position angle and distance of about 120 stars made with a bifilar micrometer. The next communication of the kind, in 1896 March, was a list of observations made in 1894 and 1895 with the new 28-inch refractor, for that instrument was given wholly into Lewis's charge, and with it he continued to make observations of double stars. This work was occasionally diversified by observations of Saturn, and as time went on others helped, so that this became an additional department of the observatory work. The results will be found in successive volumes of the *Monthly Notices* as official communications by the Astronomer Royal; further details are contained in the Greenwich volumes. These observations of Lewis are collected in the recently published Greenwich Catalogue of Double Stars.

But in addition to measures there are in the *Monthly Notices* papers in his own name on the orbits of certain binary stars that he found to be of interest, and also papers by his co-workers in the double-star department that were inspired by him. Several of the orbits computed by him still satisfy the observations well, in particular that of κ Pegasi, an extremely close double star with a semi-major axis of only $0''{\cdot}29$ and the very short period of 11·35 years.

Special mention should be made of the volume he prepared on the stars to be found in Wilhelm Struve's *Mensuræ Micrometricæ*, published as volume 56 of the *Memoirs* of the Society, in which he collected for each star the observations made by Struve and by others since his time, and

in many cases Lewis suggested an orbit or made some critical remark. For this he was awarded the Lalande Prize of the Paris Academy in the year 1907.

Lewis was born in London on 1856 June 12 but passed his early life at East Dougland, near Wivenhoe, Essex. Early in life he lost his father, who was a captain in the mercantile marine, by disaster at sea. In 1867 he entered the section of the Royal Hospital School at Greenwich, known as the Upper School, before the reorganization of that institution into its present form, and came under the instruction of the Rev. James Hill. He maintained his connection with the school until 1875, when he entered the College for training Naval Teachers, then newly established at Greenwich; after completing the course, and some service as a schoolmaster, he passed by Civil Service examination into the Devonport Dockyard School as Assistant Master in 1879, and left in 1881 to take up, after further examination, the post at the Royal Observatory rendered vacant by the retirement of Mr. Lynn. He married, in 1907, Marie Elizabeth, daughter of William Robert Wills of Dinas Powis, Glamorgan. Two children were born to them, of whom the younger, a boy, died in infancy; his widow and daughter survive him. Lewis retired from his position in the Royal Observatory on 1917 September 30, and lived the later years of his life at Wivenhoe, where he died in the hospital on 1927 June 5 after a serious operation. He was buried in the cemetery of that town on June 10 in the presence of representatives of various bodies with which he had been connected during his life, among them being the Craft of Freemasonry of which he had been an enthusiastic member.

Lewis was elected a Fellow of the Society on 1884 December 12: he served on the Council from 1902 to 1912 and as Secretary from 1905 to 1909.

Louis George Macrory was born in Ireland on 1865 May 25. He studied medicine at Dublin University, where after a brilliant career he graduated M.D., B.Ch., with special distinction in midwifery. He carried on general medical practice for twenty-one years in Battersea Park, and for a further twelve years in Worcester Park. During the war he served as radiographer at the Belmont Hospital. Much of the small amount of leisure from a busy professional life was spent by Dr. Macrory in his observatory at Battersea, which included a 4-inch refractor by Grubb, mounted equatorially, and driven by a clock once used by Dr. Common for his famous 60-inch reflector. Dr. Macrory was keenly interested in anything mechanical or electrical, and was one of the earliest of motorists. He attempted in the early days of motoring to drive a car round the world, but failed owing to the difficulty of obtaining spare parts. He died at his residence, Chesterfield, Worcester Park, on 1927 April 11, leaving a widow, two sons, and a daughter.

He was elected a Fellow of the Society on 1903 December 11.

William Cunliffe Margerison of York House, Knaresborough, a partner in the firm of Margerison & Co. of Canal Road, Bradford, wool merchants, died on the 9th day of November last.

Mr. Margerison, who was born on 1877 January 20, at 4 Porchester Gate, London, W., and was educated at Harrow, took a keen general interest in astronomy. He married in 1919 Mary Gertrude Blaylock of Blackpool, and leaves issue, one daughter, Mary Alice, born 1920 April 20.

He was elected a Fellow of the Society on 1921 January 14.

Rev. William Francis Rigge, S.J., was born in Cincinnati, Ohio, on 1857 September 9, and was the youngest member of a family of eight children. His parents were poor, and in the school of necessity he had instilled into his life lasting habits of perseverance and industry which never failed him during his long and fruitful career. Despite the poverty of the family he was given a thorough elementary education, and in his seventeenth year he went to the Novitiate at Florissant, Missouri, to become a Jesuit. After the many years of training common to the members of that Order, he was ordained to the priesthood by the late Cardinal Gibbons at Woodstock, Maryland, where he had made his theological studies. It was at Woodstock also that he received, from the Rev. John T. Hedrick, S.J., the grounding in astronomical studies and methods which influenced to so great an extent his future work. He began his teaching career at Creighton University, Omaha, at the inception of that institution in 1878, and, excepting the years devoted to his professional studies and training as a Jesuit, he spent most of his life in the classroom at St. Ignatius College, Chicago; St. Louis University, St. Louis; and Creighton University, until failing health made it necessary for him to be relieved of this duty. In 1891, and again in 1895, he went to Georgetown University, Washington, D.C., where he worked and studied under the guidance of the Director of the Observatory, Father J. G. Hagen, S.J., now in charge of the Vatican Observatory. In 1896 he returned to Creighton University, where he remained as Professor and Director of the Observatory until his death.

Father Rigge was a most industrious worker; he published in *Popular Astronomy*, in the *American Mathematical Monthly*, in *School Science and Mathematics*, in the *Scientific American*, and in other periodicals some five hundred articles; and in his declining years he devoted his remaining energies to the publication of two books. The first of these, of special interest to the astronomer, is his work on *The Graphic Construction of Eclipses and Occultations*; the other is his treatise on *Harmonic Curves*, and is of special interest to the mathematician.

Father Rigge, however, was by no means a hermit, and he made many friends; a genial as well as a pious man, he was devoted to the welfare of the young men, some three thousand or more in number, who during his long career as a teacher were entrusted to his care for training along scientific lines: he endeavoured to instil into their lives high ideals, and by the example of his own life even more than by word of mouth he taught them how to combine the love of God and the love of science, and to find in the beauties of nature, as revealed and enhanced by science, an image of the uncreated Beauty from which they received all their perfection. He died at Omaha on 1927 March 31.

He was elected a Fellow of the Society on 1909 June 11.

Rev. William Smith was born at Warrington on 1844 October 6. Shortly afterwards his parents moved to St. Helens. There he came under the spiritual influence of the Rev. J. Mould, minister of the Baptist Church at St. Helens, and at the age of eighteen he became a local preacher. Five years later, having creditably passed the essential examinations, he was received into the ministry and sent to the Blackburn Circuit. Thus began a long ministry in various parts of England, until in 1910 Mr. Smith retired from active work and went to live in Yorkshire. But the frequent air raids on the East Coast had seriously impaired his health, and so in 1920 he and his wife moved to Hove. Here his chief interests were centred in his church at Goldstone Villas and his favourite study, astronomy.

Throughout his life Mr. Smith was a diligent student, being especially interested in the Latin and Greek languages, comparative theology, and several branches of natural science. He had distinct administrative gifts and rendered good service to his Church in this direction, as well as in his pastoral work and in the pulpit.

He died at Hove on 1927 March 3. He had married in 1872 the eldest daughter of the Rev. W. Rowe, and his widow and two sons survive him.

He was elected a Fellow of the Society on 1880 January 9.

John Tatlock was born in Williamstown, Massachusetts, on 1860 March 12. He was the son of the Rev. John and Lucy Whitman Tatlock. His father was long connected with Williams College as Professor of Mathematics, and the son graduated from the College with the degree of A.B. in 1882. Three years later he received the degree of A.M.

For several years after graduation Mr. Tatlock was actively engaged in astronomical work, first, for a year, as assistant at the Washburn Observatory, Madison, Wisconsin, under Professor E. S. Holden, then as Professor of Astronomy at Beloit College, Wisconsin. He removed to New York and became an actuary with the Mutual Life Insurance Company in 1889 and President of the Washington Life Insurance Company in 1904; later he turned to banking and established the Westchester Avenue Bank in the Bronx, New York City. But he always kept up his interest in astronomy and regularly attended the meetings of the American Astronomical Society. He was also President of the New York Academy of Sciences for several years before his death.

He died at the Corey Hill Hospital, Brookline, Massachusetts, on 1926 January 3, after an operation which had been preceded by several months of critical illness. His wife survives him.

He was elected a Fellow of the Society on 1892 November 11.

Antonio Vela-Herranz was born in the year 1865 in Pardos, a small town in the province of Guardalajara, Spain. In the course of his studies at the Institute of this town he showed such aptitude that the Deputies of the province enabled him to go to Madrid University to study science, where he soon graduated as a Doctor of Science. After becoming Assistant Professor in the Faculty of Sciences in 1894, he

was elected in 1908 Professor of Astrophysics, a subject which he taught to the day of his death. In 1884 he had been attached to the staff of Madrid Observatory as assistant, being promoted Astronomer in 1889. His special studies were Meteorology and Astronomy of Position. He observed the total solar eclipses of 1900 and 1905, and calculated the eclipse of 1912—of especial interest to Spain, and of general interest as being a border-line case between a total and an annular eclipse. His observations for latitude and longitude in different localities in Spain and at the Observatory entailed a very large number of meridian observations of stars, ending in the compilation of a catalogue. In 1919 he was made Director of the Observatory, a position which he held to the time of his death. During this last period of his life, though weakened in health, he secured the publication of all the work on astrophysics carried out at the Observatory, and was contemplating similar publication of photometric observations of Nova Cygni 1920.

Dr. Vela was a man of great activity, lively intelligence, great charm of conversation, and buoyant spirits. During his youth he took up journalism, and his polemics in the cause of education led to his becoming Councillor of Public Instruction in 1895; his outstanding personality led to his election to the Spanish Royal Academy of Sciences in 1919. He died on 1927 June 8 at Madrid, leaving four children.

He was elected a Fellow of the Society on 1922 March 10.

Gustav Müller was born in 1851 at Schweidnitz in Silesia. His father died when he was six years old, but his mother's sacrifices and his own industry secured him a University education. At Berlin he attended the classes of Weierstrass and Helmholtz, and, rather from force of circumstances than choice, turned to Astronomy. He worked for some time in the office of the *Berliner Jahrbuch*, and for a time assisted Auwers in the reduction of Bradley's observations. He was introduced by Förster to Vogel, who was at that time busy with the establishment of the Astrophysical Observatory at Potsdam. He assisted Vogel in spectrophotometric measures of the distribution of light on the Sun's disc, and thus began his long-continued researches in Astrophotometry. He went to live at Potsdam in 1877, and assisted in the erection and installation of the instruments of the Observatory. He commenced his very important photometric work on the brightness of the planets, which was completed and published in 1893. This included 17 asteroids as well as the planets, with very careful determinations of the differences depending on phase. Müller also assisted Vogel in the Potsdam Spectroscopic Durchmusterung of the stars brighter than $7^{m}.5$.

In 1886 Müller and his friend Kempf commenced the great photometric work which occupied them twenty years—the *Potsdam Durchmusterung*, giving the visual magnitude and colour of all stars in the northern heavens down to the magnitude $7^{m}.5$. This work is of the highest accuracy, and is a monument of the skill and perseverance of its two authors. Soon after this was finished he began a photometric determination of all the stars in the Bonn Durchmusterung within 10°

of the North Pole. The work was delayed by the War, and has only just been published by Dr. Hassenstein. As indicating the readiness of Müller to co-operate with other Astronomers, it may be mentioned that in 1913 he kindly sent to Greenwich the results obtained to that time, in order that the differences between visual and photographic magnitudes of the stars of Carrington's Catalogue might be compared with the proper motions.

At the meeting of the *Astronomische Gesellschaft* in 1900 Müller suggested the formation of a great catalogue of variable stars. The scheme widened and resulted in three large volumes by Müller and Hartwig, giving the history and literature of 1687 variable stars up to 1915, followed by a catalogue of the elements of their light changes. Taking Algol as an example, a concise history is given occupying one page, and then follow three pages of references from the first observation of Montanari on 1670 November 8 to the observed times of minima on 1915 August 14 at Bamberg. This great undertaking has earned for Müller and Hartwig the gratitude of all who study variable stars.

In 1882 Müller was chosen by Auwers as leader of the German Expedition to Hartford, Conn., U.S.A., to observe the Transit of Venus. He observed the eclipse of 1887 in Russia and that of 1900 in Portugal, and to measure the absorption of light by the atmosphere he visited Säntis in 1889, Etna in 1894, and Teneriffe in 1910. He thoroughly enjoyed expeditions of this kind, a not uncommon experience of astronomers.

Müller was Secretary of the *Astronomische Gesellschaft* from 1896 to 1924 and never missed a meeting. He entered the Observatory at Potsdam in 1877, became a principal observer in 1888, and received the title of Professor in 1891. On the death of Vogel he probably would have been appointed Director but for the outstanding eminence of Schwarzschild, whom he served with the greatest loyalty. After Schwarzschild's death he was appointed Director, and retired in 1921. For these personal details, and for some references to his scientific work, the Council are indebted to the notice in the *Vierteljahrsschrift* of 1925 by his successor, Professor Ludendorff.

He was elected an Associate of the Society in 1905.

F. W. D.

Jens Frederik Wilhelm Schroeter died 1927 April 27 after a few days of acute illness. He was born on 1857 May 21 in Oslo, but the family soon moved to the town of Drammen, where Schroeter spent most of his boyhood.

His mind was drawn towards astronomy in early years when travelling at sea with his father, who was a shipmaster, and this origin of his astronomical interest betrayed itself in several respects in his subsequent activity, inasmuch as he always retained a keen interest in questions concerning navigation and practical astronomy. Schroeter received his master's degree in natural sciences at Oslo University in 1882, and practically all his life afterwards was devoted to scientific activities of miscellaneous kinds. Thus in the next two years he worked at the Norwegian Arctic Station at Bosekop, which was erected for the study of terrestrial magnetism and meteorological

phenomena. Subsequently he became an assistant at the Meteorological Institute at Oslo, where he stayed four years (1884–88). At the end of this period he was fortunate enough to obtain a grant enabling him to travel abroad and to familiarise himself with current astronomical activities in Europe. He thus visited the Observatories of Strasbourg, Potsdam, and Pulkovo, which at that time were recognised centres of active research. After returning to Norway from this trip he was appointed *observator* at the Observatory of the University at Oslo (1891), and in this position he stayed twenty-eight years until he succeeded Geelmuyden as Professor of Astronomy and Director of the Observatory (1919).

Amongst the scientific work of Schroeter, his meridian observations of stars in the zone 65° to 70° north declination, and the derivation of proper motions for these stars, come in the first place. The observations were carried out in co-operation with Professor Geelmuyden, and the fact that this work is of recognised scientific standing, in spite of the admittedly poor equipment of the Observatory, is a good indication of the zeal and scientific skill of its authors. In 1923 Schroeter published the results of his work on European solar eclipses, *Sonnenfinsternisse von 600 bis 1800 n. Chr.*, which is mainly intended as a guide for the accurate fixing of historic dates. Shortly before his death he completed an imposing work on chronology, written in Norwegian, *Haandbog i Kronologi*, in two volumes. He also published numerous minor articles in scientific periodicals and textbooks on astronomy for elementary schools. He contributed to the dissemination of astronomical knowledge in his country by translating foreign astronomical literature into Norwegian, and by giving long series of popular lectures on astronomical subjects.

Schroeter was of a charming personality; as especially winning traits may be mentioned his keen sense of fair play and his uncompromising distinction between personal and scientific matters. He was far from having the narrow view of science frequently found among specialists. Characteristic of his trend of thought was his interest in the history of astronomy in particular, and the historic point of view in general. He was frequently consulted by historians on chronological matters, where he exerted an unrivalled authority. He was singularly free from prejudices against modern points of view in science. Thus his attitude towards the relativity theory, when it was brought into the focus of general attention by the measurements of the bending of light rays in the sun's gravitational field, was absolutely unprejudiced. In spite of his advanced age he did not feel that his life's work was at a close, and he had a wide programme for future work. He desired particularly to write a monograph on Hansteen, the first astronomer at Oslo University, under whose auspices the Observatory was erected. He was a member of the Norwegian Academy of Science.

He was elected an Associate of the Royal Astronomical Society on 1923 November 9.

[The Council are indebted to Professor S. Rosseland for the above notice.]

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir Frank Dyson, K.B.E., Astronomer Royal.*)

Transit-Circle.—The number of transits during the year was 10,122, including 141 of the Sun and 83 of the Moon. The observations are reduced to epoch 1925·0 as far as 1927 July. The ledgers of clock stars, azimuth stars, and zone stars are complete to the end of 1925. In addition to the observation of stars down to magnitude 8·0 and between declination + 32° and + 64° commenced in 1922, observations are being carried out on a selected list of 493 stars north of declination −15° which will be used as reference stars for the observation of Eros in the opposition of 1930–31. An investigation of the Greenwich Declination Observations of 55 bright clock stars, from the erection of the Transit-Circle in 1850 to the end of 1925, has been undertaken and the results published in the *Monthly Notices* for 1927 May. A similar discussion is now being carried out on the bright stars north of the clock star zone.

Altazimuth.—The programme of observations of transits across the prime vertical of stars in Boss's Preliminary General Catalogue was completed in January. The results will be published as a separate Greenwich volume. The declinations obtained from the Altazimuth transits between + 11° and + 45° for the epoch 1925 are in close agreement with the declinations given by Eichelberger.

At the end of January the instrument was set in the meridian again, and all parts were thoroughly cleaned and adjusted. It has since been used for observations of clock and azimuth stars, with a view to checking the clock errors obtained with the Transit-Circle, and also for observations of the places of stars which will be used as comparison stars during the forthcoming opposition of Eros. In all, 903 transits and a similar number of zenith distances were observed during the year.

Cookson Floating Zenith Telescope.—The number of plates taken during 1927 for variation of latitude is 212. They are fairly well distributed throughout the year, but there was a deficiency of plates in June. In addition, 8 plates for scale were obtained. The measurements and reduction of the year's plates are in hand and should be completed by March.

The results for the year 1926 were published in the *Monthly Notices* for 1927 March. The final reduction for the second period of seven years has been completed and the copy for press is being made.

28-inch Refractor.—During the year 480 observations of 301 double-stars were made. Arranged according to separation they are :—

Under 0″·5	150 observations.
0″·5–1″·0	153 ,,
1″·0–2″·0	114 ,,
Over 2″·0	63 ,,

A catalogue of the stars which have had three observations, similar to the one in the volume for 1920, has been published in the volume for 1925.

On Sunday nights and on other nights when the instrument is not in use for double-star observations, it is employed by Dr. Steavenson for the observation of faint variable stars.

Thompson Equatorial.—During the year 753 plates have been taken for parallax with the 26-inch refractor, and 527 plates measured. The parallaxes of 33 stars were published in the *Monthly Notices* for 1927 November.

The programme of observations with the 30-inch reflector of the relative colour temperatures of B- and A-type stars, referred to in last year's report, was completed early in the year, and the results for 22 stars published in the *Monthly Notices* for March. A more extended programme of a similar nature has been commenced, which includes all stars of types B and A north of the equator and down to magnitude 3·0. Fifty-four pairs of stars were compared during the year, including 31 pairs belonging to the new programme. Five plates were also obtained for the verification of the grating constant. Owing to the prism being required by the expedition sent to observe the Solar Eclipse of 1927 June 29, the camera was dismantled for the greater part of the summer, during which period the telescope was used by Dr. Merton for the direct photography of comets. Thirteen comet plates were obtained by him.

The volume of determinations of effective photographic wave-lengths of stars down to magnitude 10·5 and between declination + 80° and the Pole, referred to in the reports for previous years, has been published and distributed.

Astrographic Equatorial.—During the year 70 fields were photographed through the glass for the determination of proper motions of stars in the Greenwich Astrographic Zones. Zones 64° to 71° inclusive, comprising vol. i. of the Astrographic Catalogue, have now been completely rephotographed, and the copy for press has been prepared for Zones 64° to 69°. In the course of measuring the plates some errata in vol. i. of the Astrographic Catalogue have been noted. In the course of this work 222 proper motions greater than 20″ a century in one co-ordinate have been found between declinations 64° and 72°. Of these, 42 are greater than 40″ a century, and 29 of the 42 are greater than 50″ a century. Eleven of these 29 proper motions are new.

The largest proper motions found in the year are those of 71·532 which is moving parallel to 66·34, and of a pair of stars 2′ apart, viz., 70·4336 and 70·4337. The proper motions are as follows :—

	Magnitude.	P.M. in R.A.	P.M. in Dec.
Ast. Cat. 71·532	10·8	+172″·8	−40″·2
66·34	11·3	+173·1	−27·2
70·4336	11·8	− 65·9	−30·9
70·4337	12·6	− 66·6	−30·3

Dr. H. de Groot has carried out a statistical discussion of double-stars with separation less than 30″, which are found in Zones 64° to 69° of the Greenwich Astrographic Catalogue. This discussion has been published in *Monthly Notices*, **88**, 51.

Short Focus Cameras.—Dr. Merton made several successful exposures on comets with his two short-focus cameras which are mounted on the astrographic telescope.

Miscellaneous Equatorial Observations.—Three disappearances of stars occulted by the Moon were observed. The Transit of Mercury 1927 November 10 was observed, and the results published in the *Monthly Notices*.

Photoheliograph.—Photographs of the Sun were obtained on 248 days at Greenwich and on 338 days at the Cape. On 4 days photographs were not taken at either Observatory, but on 3 of these days negatives are available at Kodaikánal. A new Ross enlarging lens, of similar design to the one supplied last year by Messrs. Ross, Ltd., for the Thompson Photoheliograph, has been fitted to the 4-inch photoheliograph. The new lens gives very satisfactory results.

The mean daily spotted area for the year, corrected for foreshortening, is approximately 1100 millionths of the Sun's hemisphere. The published values for the preceding three years 1924, 1925, and 1926 are 276, 830, and 1262 respectively.

Clock and Time-Service.—The free pendulum (Shortt No. 3) has been used as sidereal standard throughout the year. Shortt No. 11 has been kept as a reserve clock, regular comparisons being made with Shortt No. 3. The performance of both clocks has been very satisfactory.

A free-pendulum clock (Shortt No. 16) adjusted to mean time, with an additional controlled clock pendulum giving 61 double swings per minute of mean time, has been installed for use in transmission of wireless time-signals through the General Post Office station at Rugby. This service was commenced on December 19, and signals have been transmitted at 10^h and 18^h daily. The signal series consists of rhythmic beats conforming to the international system used by the Bureau International de l'Heure, Paris, and lasts for a period of five minutes, the last signal being made at the hour. The Rugby signals are observed at Greenwich with a view to getting out and publishing final corrections.

Hourly signals to the Post Office and half-hourly signals to the British Broadcasting Corporation have been maintained.

A four-valve W/T receiving apparatus by the Marconi W/T Co., Ltd. (Type R.P. 11), with open aerial phasing unit supplementary to the normal frame aerial, was purchased in July. The receiver covers the range of wave-lengths from 15,000 to 22,000 metres and is very selective.

It has assisted materially in maintaining regular reception with minimum interference of the long wave time-signals, especially those from Annapolis. The comparisons with the Greenwich clock of the time-signals from Annapolis, Eiffel Tower, Nauen, and Bordeaux have been made regularly during the year.

Observations with Transit B.—The special series of observations made with the small reversible transit B in connection with the longitude observations of October and November 1926, showed that there was a systematic difference between the time observations with this instrument and with the large transit instrument. In order to study this difference and to get absolute time determinations, observations were made with Transit B on 31 nights. A few transits of the Moon and Jupiter were also observed.

Eclipse of the Sun.—An expedition went from the Observatory to observe the total eclipse of 1927 June 29. The principal part of the programme was to photograph the corona on a large scale with a 6-inch lens of 45-feet focus, to photograph the spectrum in the infra-red with a Littrow spectrograph, and to compare the intensity of the Ca − doublet in the infra-red with the H and K lines by means of a small dispersion Littrow spectrograph. The weather previous to the eclipse was extremely bad, but the eclipse itself was observed through a break in the clouds. Small scale photographs were also secured from an aeroplane. A full report is given in *M.N.*, **87**, 657.

The attempt to compare the Ca + doublet with H and K at the eclipse failed, but sufficient information was obtained to suggest the possibility of carrying out a comparison without an eclipse. This was accomplished subsequently at Greenwich, and the result published in *M.N.*, **88**, 30. The comparison indicated that the total integrated intensity of the line 8542 was somewhat greater than that of K at moderate levels.

At Giggleswick a colour film of the eclipse was taken by the British Polychromide Co., Ltd. A discussion of this film has been made in *Monthly Notices*, **88**, 142. It appears that a film of an eclipse carrying an accurate time scale might give information about the height of the chromospheric layers and the exact time of mid-totality.

Printing.—The volume of Greenwich Observations for 1925 and its separate parts have been distributed, together with the volume of effective photographic wave-lengths referred to above. A small volume containing the results of the time observations and comparison of W/T signals carried out in 1926 in connection with the international longitude scheme has also been distributed.

The printing of the Greenwich Observations for 1926 is well forward, and the MS. of a volume of Declinations of Stars from Observations of Transits across the Prime Vertical, made with the Altazimuth in the years 1923–1926, is in the hands of the printers.

Miscellaneous.—Dr. Crommelin retired on May 11 after thirty-six years of service. His enthusiasm for, and wide general knowledge of, astronomy have been a great asset to the Observatory. Dr. Merton has worked at the Observatory during the year, and in addition to his work on comets has taken regular observing duties with the 26-inch refractor. During the first six months of the year Mr. Horrocks worked

regularly at the Observatory and took a large number of routine observing duties, in order to gain experience prior to taking up an appointment as Chief Assistant at the Royal Observatory, Cape of Good Hope.

Royal Observatory, Edinburgh.
(*Director, Prof. Sampson, F.R.S., Astronomer Royal for Scotland.*)

Close attention has been given to the determination of time both with the transit-circle and by the daily comparison with the micro-chronograph of the four principal clocks, Riefler No. 258, Shortt No. 0, Shortt No. 4, and Leroy No. 1230.

The reception and recording of the wireless time-signals from Bordeaux, Nauen, and Annapolis have been regularly carried on. In the beginning of June great trouble was experienced in the reception of the Annapolis signals owing to interference from other stations. This continued until the latter part of October when the aerial of three parallel strands was replaced by a single strand. Since this alteration very little trouble has been experienced.

The Daventry signal from Greenwich at 10·30 was also taken, until the G.B.R. signal at ten hours was inaugurated and replaced it.

With the Cooke 6-inch photo-visual telescope and objective prism, the spectra of stars down to the third magnitude are under re-observation, and photograms of the spectra observed have been made with the Koch photometer.

The laboratory work with the Koch photometer has been continued and further results are to be published shortly.

The solar spectroscope has been in use for the purpose of obtaining plates for the determination of the equatorial value of the solar rotation.

This spectroscope was adjusted and all preparations made with a view of obtaining the "flash" spectrum during the large partial solar eclipse on June 29, but clouds prevented any observation.

Measures of the magnitude of stars of the Perth (W.A.) astrographic plates have been continued. The position as regards the publication of these measures remains unchanged.

The construction of the new 36-inch Cassegrain reflector and spectrograph is proceeding actively, in the hands of Sir Howard Grubb, Parsons & Co., and Adam Hilger, Ltd.

Royal Observatory, Cape of Good Hope.
(*Director, Dr. H. Spencer Jones, H.M. Astronomer.*)

Reversible Transit-Circle.—Observations of the programme commenced in 1925 have been continued. This includes all stars south of $-30°$ Dec. and brighter than $7^{m}\cdot5$, together with the zodiacal stars in the *Cape Catalogue* for 1900. At the request of Professor Eichelberger, 156 stars contained in Hedrick's *Zodiacal Catalogue*, for which modern places are not available, have been added to the working list. The stars under observation at the Rio de Janeiro Observatory for the

determination of latitude variation, whose positions have not been determined with the reversible transit-circle, have also been added to the working list. Observations were commenced of the second list of Eros reference stars. The list contains 402 stars in 66 minutes of right ascension ; within the same limits of right ascension the current working list contains 620 stars. Two more years will be required to complete the observation of these stars.

The number of meridian transits observed during the year was 9257. The Sun was observed on 194 days, Venus on 133 days, and Mercury on 71 days. Current reductions are well advanced.

Heliometer.—The following observations of the major planets at their oppositions have been secured :—

Opposition of Neptune	.	60 obs. in distance		on 5 nights.
,, ,, Saturn	.	48 ,, ,, ,,		,, 8 ,,
,, ,, ,,	.	24 ,, ,, position angle		,, 5 ,,
,, ,, Jupiter	.	48 ,, ,, distance		,, 9 ,,
,, ,, ,,	.	48 ,, ,, position angle		,, 9 ,,
,, ,, Uranus	.	72 ,, ,, distance		,, 10 ,,

Victoria Telescope.—The telescope was in use on 279 nights during the year for stellar parallax determinations. 2029 plates were secured, of which 67 have been rejected for various reasons as unsuitable for measurement. 213 stars are at present under observation. The number of plates measured during the year was 2105.

One out-of-focus plate of the ω Centauri cluster was taken at the request of Professor Schlesinger.

Astrographic Telescope.—The following plates were taken with this instrument :—

	No. of Plates.	No. of Exposures.
Cape Astrographic Zones (for proper motion)	334	1336
Comet Blathwayt, 1927 *a*	15	17
Comet Reid, 1927 *b*	7	7
Comet Pons Winnecke, 1927 *c*	13	16
Comet Stearns, 1927 *d*	3	3
Comet Gale, 1927 *f*	3	3
Comet Skjellerup, 1927 *k*	2	2
Nova Aquilæ region	1	2
Nova region ($5^h\ 15^m$, $-67°$)	5	20
C.P.D. region	1	2

256 plates were measured during the year against plates of the earlier C.A.Z. series for the derivation of proper motion. The measurement of zones $-41°$ to $-45°$ is now complete.

Photoheliograph.—701 photographs of the Sun to supplement the Greenwich series were secured on 338 days during the year. Visual observations for zero were made weekly. Original negatives to September 24 and duplicates to October 22 have been forwarded to Greenwich.

Occultations.—Eight observations of disappearance at the dark limb, three of disappearance at the bright limb, and two of reappearance at the dark limb were secured.

Time-Service and Wireless Time-Signals.—Time-signals have been sent out regularly to the Post Office and the Broadcasting Association, as well as wireless time-signals *via* the Slangkop wireless station. The apparatus for the automatic emission of the international type of time-signal, ordered from the firm of Belin of Paris, has not yet been received. The apparatus was tested by M. Bigourdan at the Bureau de l'Heure, and various adjustments found to be necessary. The apparatus has now been approved. The Observatory is greatly indebted to M. Bigourdan for the thorough testing to which he has subjected the apparatus.

The scientific rhythmic signals sent out from Bordeaux (8^h 1^m to 8^h 6^m G.M.T.) were observed on 250 days. A new 8-valve Marconi receiver (Type R.g. 12), which is used in conjunction with a directional frame aerial and 35 ft. vertical aerial, is under trial. It is hoped that the high selectivity and directional properties of this apparatus will secure greater freedom from the disturbing effects of other stations and of atmospherics. In particular, it is hoped that it will be possible to receive regularly the Greenwich signals sent out *via* Rugby. The results of the trials to date are promising.

Publications.—*Cape Independent Day Numbers* for 1929 has been published.

Cape Astrographic Zones, vol. 9 ($-49°$) and vol. 11 ($-51°$) have been published. These two volumes complete the Cape section ($-41°$ to $-51°$) of the *Carte du Ciel* work.

Photographic Magnitudes of the Cape Zone Catalogue.—This catalogue gives the photographic magnitudes of the 20,843 stars contained in the *Cape Zone Catalogue* for 1900. The introduction to the catalogue contains a discussion of the results. The whole of the proof sheets have been passed for press.

Results of Meridian Observations, 1918–1925 (*Cape Annals*, vol. xiii., part 2) has been published.

First Cape Catalogue of Stars for the Equinox 1925.—The manuscript of this catalogue, which is based upon observations secured with the reversible transit-circle during the years 1918 to 1925, has been sent to the printer. A portion of the first proofs has been received.

Radial Velocity Determinations (*Cape Annals*, vol. x., part 8) has been sent to press, and a portion of the first proofs has been received. It gives the results of the radial velocity determinations secured with the Victoria Telescope and not hitherto published in the *Cape Annals*. Section A contains the details of the spectroscopic determination of the constant of aberration, a summary of which has been published in the *Monthly Notices*; Section B contains the determination of the orbital elements of 13 spectroscopic binaries; Section C gives the individual results of the radial velocity determinations, with a discussion for solar motion and star streaming.

Personal.—Dr. Halm retired in July on the completion of twenty years' service as Chief Assistant, during which time he took an active

interest in every branch of the Observatory work. Mr. Horrocks of St. Catherine's College, Cambridge and Isaac Newton Student in the University of Cambridge, was appointed Chief Assistant, and arrived at the Observatory on August 30.

Armagh Observatory.
(*Director, Rev. Wm. F. A. Ellison.*)

Double-star measures with the 10-inch Grubb equatorial have been continued during 1927. The results are published in *Monthly Notices* from time to time. The last series appeared in the March number, vol. **87**, No. 5. The present programme is the measurement of all pairs under 10″ in the *Potsdam Catalogue.*

The 6-inch equatorial continues to be used mainly for solar and lunar work, and for exhibiting objects to occasional visitors.

A good series of drawings of Mars was obtained at the Opposition of 1926 November, and after. The 10-inch telescope, and when atmosphere was favourable the 18-inch reflector, were used for this.

The Transit instrument is occasionally used for time, but the clock checking is now mainly done by the wireless signals.

All the instruments are in good order, except the 7-inch Mural Circle, which has not been used for very many years.

The direction portion of Dr. Robinson's original Anemometer, which was returned to the Observatory by the South Kensington Museum some time ago, has been re-erected in its original position, and can be seen in action: though of no scientific importance, it has considerable historical interest.

Much more could be done with the instruments in existence, and more still with one or two additions to them, but for the serious shortage of funds. The Government of Northern Ireland, recognising the national importance of the Observatory, have recently made the Governors an annual grant of £100. This will be just sufficient to avert actual decay. Considerably more would be required before any actual advance could be made. Previous to the grant, the total income of the Observatory was only £276.

Cambridge Observatory.
(*Director, Professor A. S. Eddington, F.R.S.*)

The Sheepshanks telescope has been used mainly in trial work with the photoelectric photometer. After much discouraging experience one cell has been found to give fairly promising results, and it is hoped that better progress may now be made. In the intervals when the photometer was dismounted, 8 photographs for proper motion and stellar magnitudes were taken.

Five regions have been measured for determination of proper motions. Two publications are now in the press, viz. a catalogue of photographic proper motions of 3275 stars, and a catalogue of zodiacal

stars from meridian observations in the years 1900–1918. These will bring the publication of the work of the Observatory fully up to date.

Mr. Smart accompanied the eclipse expedition of the Solar Physics Observatory to Aal, Norway, which was unsuccessful through cloud. The third contact of the transit of Mercury on November 10 was successfully observed by Mr. Green.

Professor J. J. Nassau, Director of the Warner and Swasey Observatory, Cleveland, U.S.A., who is spending a year in Cambridge, and Mr. R. O. Redman, Isaac Newton Student, have been engaged in statistical researches, the former on trigonometrical parallaxes, and the latter chiefly on dynamical parallaxes. Dr. T. H. Osgood of Manchester University visited the Observatory for a short time for the purpose of measuring 50 photographs of double stars which he had taken at Mount Wilson Observatory.

Solar Physics Observatory, Cambridge University.
(Director, Professor H. F. Newall, F.R.S.)

Spectroheliograph.—Photographs of the Sun's disc in K_{232} light were obtained on 108 days (previous year, 114); and photographs of the prominences at the Sun's limb were obtained on 92 days (previous year, 94).

The solar activity was well maintained during the first half of the year, but diminished during the later months. Towards the end of December a slight increase occurred, but the comparatively small extent of calcium flocculi accompanying the disturbances appears to indicate that the maximum may have been reached in 1927.

In the study of spectroheliograms, selected compact calcium flocculi are being measured for the determination of the motions involved in their growth from day to day.

For the year 1926 October 1 to 1927 September 30, the Director of the Kodaikánal Observatory has sent 334 spectroheliograms showing the Sun's disc in K_{232} light.

Bromide prints of 456 photoheliograms from negatives taken at the observatories at Greenwich, the Cape, and Kodaikánal have been received from the Astronomer Royal, for 1925 October 1 to 1926 December 31.

Study of Sun-spot Records and Prominences.—The investigation of the evidence of the existence of related sequences of outbursts of sun-spots has been continued. The material relates to the four 11-year cycles 1879–1923.

The records of prominences obtained at the Kodaikánal Observatory during the year 1926 and received in MS. through the kindness of Dr. Royds have been plotted in continuation of the previous observations.

Total Solar Eclipse 1927 June 29.—A large amount of work was expended in preparing for observations of the eclipse 1927 June 29. An account of the expedition to Aal (Hallingdal) in Norway was printed in the *Monthly Notices* (**87**, 676). Observations were completely frustrated by thick cloud.

Studies of Stellar and other Spectra.—With a grating spectrograph attached to the Newall Telescope attempts have been made to photograph the infra-red regions of certain stellar spectra. In spite of the fact that the grating used gives a very bright spectrum of the first order, it has not been found possible to get records of the Ca II. lines in stellar spectra without inordinately long exposures; and further efforts have been abandoned.

Some new identifications of lines of ionized iron with lines in various celestial spectra have been made, and the results of the work have been communicated to the Society (*M.N.*, **87**, 470).

The spectrum of α Andromedæ has been studied from the material of 75 spectra taken with an objective prism at South Kensington before 1912. More recent spectrograms have been secured with a slit-spectrograph at Cambridge with a view to a closer investigation of the peculiarities of that spectrum.

The work on widened lines in sun-spot spectra has been continued.

The recent suggestive work on the origin of the nebular lines has stimulated a search for the possible origin of the so-called "Coronium" lines of the spectrum of the Solar Corona. Hitherto the effort has not met with any success.

A paper on the "Intensity of an Absorption Line in a Spectrum produced by a Grating" has been communicated to the Society (*M.N.*, **88**, 154).

Meteorological Physics.—The study of the vertical electrical fields and currents due to shower clouds and thunder clouds has been continued. Some improvements have been made in the method of photographic registration employed in the observations.

An account of the results of preliminary observations on the currents due to point-discharges beneath cumulo-nimbus clouds has been published in the *Proceedings of the Royal Society* (vol. **115**, 443).

Dunsink Observatory.
(*Acting Director, Mr. Charles Martin.*)

The time-service to Dublin has been continued as in previous years. The meridian circle has been used only for time determination, a comparison being made daily between Paris and Dunsink mean time.

The Observatory has been used mainly for teaching purposes, students being welcome in the day for instrumental instruction, and any clear evening for observational work.

Durham University Observatory.
(*Director, Mr. Harold Thomson, M.Sc.*)

Following the practice of recent years the principal work of the Observatory has been the observation of long-period variable stars. The number of observations obtained during the year shows a satisfactory increase over previous years, although the weather was not

very favourable. About four years ago the variability of a star in the field of R. Ursæ Minoris, numbered 23 on Hagen's chart, was suspected. This star has been observed regularly since that date, and from the observations obtained the variability was confirmed. It would appear that the period is about 372 days and the variability between magnitudes 9·2 and 9·8.

Observations have also been carried out on comets, and on Venus and Jupiter. The transit of Mercury was observed on November 10, and third and fourth contacts were timed at $8^h\ 28^m\ 1^s$ and $8^h\ 29^m\ 36^s$ respectively.

Meteorological observations have been maintained as usual, and the results transmitted to the Meteorological Office. During May a new anemometer was added to the Meteorological equipment.

Norman Lockyer Observatory, Salcombe Hill, Sidmouth.
(Director, W. J. S. Lockyer, M.A., Ph.D.

The 9-inch Kensington Prismatic Camera has been in regular use throughout the year, mainly for the purpose of obtaining a series of photographs of the star HD20336 Camelopardalis, which has a variable spectrum. It has been used, in addition, for work on other bright line stars. The 12-inch McClean instrument has been utilised, when possible, for the usual routine photography of stellar spectra. The 10-inch visual telescope attached to the McClean instrument has been fitted with a coarse wire grating made at the Observatory. This grating is made of "Eureka" wire, 3·65 mm. in diameter, arranged so that the spaces and wires are of equal width; it is at present being used for photometric observations of ϕ Persei. During the year successful observations have been made on 97 nights, the number of negatives secured being 112 with the Kensington telescope, 2 with the fixed meteor camera, 58 with the McClean 12-inch, and 17 with the 10-inch coarse wire grating. It may be remarked that the night observing conditions during the year have been the worst since 1920, when in that year they numbered 88. The average yearly number of fine nights at this Observatory, from and including 1920, is 133.

The work on spectroscopic parallaxes has been continued, the parallaxes of 300 B-type stars and 300 A-type stars having been published during the year (*M.N.*, **87**, 364; **87**, 387). The work on bright line stars is also being continued, with special attention to the star HD20336 mentioned above.

Preparations were made to observe the solar eclipse of June 29, both in the belt of totality near Richmond, Yorks., and at the Observatory, but the weather during the critical period was cloudy at both places. A report of the expedition has been published (*M.N.*, **87**, 668) and also a note on the degree of darkness observed at the eclipse station (*M.N.*, **88**, 97).

From 1927 February 16 Mr. H. W. P. Richards of University College, London, was appointed research student for a period of twelve months in place of Dr. H. C. Woods, who completed his year on that date.

The Observatory is open to the public on Wednesday afternoons. The number of visitors who attended during the year was 406, including visits from the Scientific Society of University College of the South-West (Exeter), the Devon Association, and the South-Western Naturalist Union.

The eleventh annual general meeting of the Norman Lockyer Observatory Corporation was held in London on 1927 June 9.

Radcliffe Observatory, Oxford.
(*Director, Dr. H. Knox-Shaw, Radcliffe Observer.*)

Since the inception of the proper-motion work on the Selected Areas with the 24-inch refractor in 1909, there has been no year in which the weather was so unfavourable for this work as it was in 1927. Long-exposure plates were obtained on only thirteen nights ; the nights lost owing to the vibration trouble referred to below were very few in number. During the year 16 plates were taken on the Selected Areas, of which only 8 have been passed as being good enough for measurement. In addition, 9 test plates were taken, most of them being in connection with the magnitude equation mentioned in the last report. In order to facilitate the observational side of the programme, it has been decided to develop all those remaining (50 in number) of the plates stored undeveloped since exposure at the first epoch, and to make exposures at the second epoch through the glass on separate plates to compare with them, as is being done with the duplicate plates which were developed directly after exposure at the first epoch.

Thirty-seven plates have been measured, and the reduction of fifteen areas has been completed during the year. Of the 135 areas in the programme, 35 have now been completely reduced, and the photography of 54 areas has been finished.

A description of the systematic magnitude equation shown by the proper motions in the first ten areas reduced was published in *M.N.*, **87**, 439. The results of the further 25 areas now reduced confirm the conclusions therein set forth, particularly that the cause is a change in the adjustment of the two components of the objective made when cleaning them in 1914. A series of special test plates is being taken, and it is hoped that by means of them, and of the proper-motion plates themselves, it will be possible to free all the proper motions from this error. The second list of stars found to have annual proper motions exceeding $0''{\cdot}1$ was published in *M.N.*, **87**, 225.

The curious periodic vibration of the telescope, which was experienced for a fortnight in January 1926, commenced again early in the year and lasted well into the summer. After considerable experiment the conclusion was reached that it was due to wear in the bearings of the telescope, and not to any outside cause. The makers were consulted, and they replaced the cast-iron rollers, which take some of the weight of the polar axis, and which had become much worn, with new ones made of steel. But the vibrations started again in November. It now seems probable that the trouble lies in the fixed bearings at the upper end of

the polar axis. These cannot be got at without entirely dismounting the telescope, but it is hoped that the trouble may be mitigated by the use of a different lubricant.

The work on Hornsby's meridian observations has been continued, a third grant having been received from the Royal Society. The reduction of the right ascensions of standard stars, Sun, and planets for the eleven years 1774 to 1784 has been completed, and that for the six years 1790 to 1795 is well advanced. Tabular places for Saturn and Uranus for comparison with the observations made in the years 1780 to 1784 have been computed by Dr. Crommelin from Newcomb's tables, but with this exception no tabular positions have been computed for the planets or the Moon. For the Moon and inner planets this is, of course, a particularly heavy piece of work, and despite the value of these observations with regard to the irregular rotation of the Earth there seems but little chance of being able to undertake it here.

The Director and Mr. H. G. Scott Barrett represented the Observatory on the joint Oxford expedition to Southport to observe the total eclipse on June 29, a report on which appears in *M.N.*, **87**, 665.

The Transit of Mercury was observed under good conditions, and the results published in *M.N.*, **88**, 119.

Radcliffe Observations, vol. **55**, part 1, containing the meteorological observations made in 1926, was published during the year.

University Observatory, Oxford.
(*Director, Professor H. H. Turner, F.R.S.*)

The extension of the library, mentioned in the last report as in prospect, was sanctioned by the University, and building operations have been in progress for some months. Four additional rooms above ground, and a basement for the seismographs will be provided. The operations have naturally somewhat embarrassed the work of the Observatory for a time, involving the temporary transference of the whole library into the lecture room, but the ultimate gain in convenience will be considerable.

The Director was absent in California during March and April, having received a very pleasant invitation to give a number of lectures, and incidentally to receive the Bruce Medal. During his absence the work of preparation for the eclipse of June 29 proceeded at the Observatory with the kind co-operation of Dr. Knox-Shaw, Radcliffe Observer. Special recognition is due to Mr. Bellamy for his activity in this work, and in the various arrangements consequent on the building operations.

A joint expedition from the University and Radcliffe Observatories accepted the invitation from the Mayor and Corporation of Southport to take up quarters at the King George V. Boys' School: the weather was not favourable, but photographs were taken through cloud, as already reported to the Society.

Zone $+56°$ of the Vatican section of the Astrographic Catalogue was completed and published, and considerable progress has been made with the tenth and last volume for the section ($+55°$). The revision of the

ledgers has been completed by Mr. Bellamy so far as is possible from the material already printed.

Volume VII. of miscellaneous papers (1921–27) has been collected and bound, and is now being distributed.

The seismological reductions have been carried on as before with the kind financial help of Dr. Crombie and of the Royal Society. Six and a half years of the International Summary have already been distributed, and the results are in proof or MS. for another eight months : a digest has been prepared of the seven years of the Summary, showing simply the time and place of each epicentre, so that a general view of seismological activity is presented : a discussion of its variation has been undertaken, and promises some results of interest, but they are not yet in final shape.

The Director attended the Prague meeting of the International Union for Geodesy and Geophysics in September, and was re-elected President of the Section of Seismology. An interesting feature of the meeting was the presence as a visitor of M. Nikiforoff, representing the large Russian organization of stations extending from Leningrad to Vladivostock. The loss of observations from these stations during the war was a serious one, and their return to work is a great gain to the science.

Dr. Fotheringham (Honorary Assistant in the Observatory) has reviewed previous studies of the mass of Venus, in some of which he has found numerical errors which affect the determined mass of Venus and to a certain extent other terms in the Sun's longitude, and he has himself determined from the Greenwich meridian observations, 1868–1916, the mass of Venus as it appears in the two largest Venus terms in the Sun's longitude. He finds that the coefficients of the terms have a common fluctuation, which could easily be explained as a fluctuation of the mass of Venus, though there are obvious difficulties in accepting this as the true explanation. It may be added that his work on the secular accelerations of the Moon and other bodies (probably to be explained as a change in the length of the day) has recently received almost sensational confirmation from the identification (by Herr Schoch) of the eclipse of Ur, 2283 B.C.

Imperial College, South Kensington.
(Assistant-Professor H. Dingle.)

The usual courses of instruction have been conducted in the Observatory and the laboratory. Preparations were made by Professor Fowler to photograph the emission spectrum of the Sun's atmosphere at South Kensington during the partial phases of the eclipse of the Sun on June 29 ; and Assistant-Professor Dingle accompanied the Cambridge expedition to Colwyn Bay on the same occasion with the object of photographing the flash and corona spectra in the infra-red region. Both enterprises were ruined by clouds. A similar misfortune attended an attempt to photograph the spectrum of the totally eclipsed Moon on December 8. Progress in laboratory work includes the publication

of investigations of the spectra of ionised nitrogen (N II) (Professor Fowler and Mr. Freeman); ionised oxygen (O III) (Professor Fowler); and neutral fluorine (F I) (Assistant-Professor Dingle). Messrs. Daly and Symons have studied the Zeeman effect for the spectrum of gold; Mr. Connelly has measured a large number of lines in the secondary spectrum of hydrogen with greater accuracy than has previously been obtained; Mr. Pretty has completed a research on the origin of the Swan spectrum; and Mr. Pearce has continued his investigation of the band spectrum of magnesium hydride.

Stonyhurst College Observatory.
(Director, Rev. E. D. O'Connor, S.J.)

We have to welcome Mr. Dudley R. Ward, B.A., on the Observatory staff. He assists in the seismological and meteorological work. At the end of the year he spent a fortnight, or a little more, at the Meteorological Office, London, with the kind permission of the Director, Dr. G. C. Simpson, to obtain first-hand experience of the work carried on there.

The issue of the monthly Seismological Bulletin has been resumed and sent regularly to the Imperial and International stations.

The meteorological, magnetic, and seismological records have been carried on as usual, and the results forwarded to the official centres.

Observations of the solar surface were made on 230 days, and include 236 drawings. Of these, 211 are complete, showing all spots and faculæ; of the remaining 25, 12 are complete for spots. The mean daily disc area of the spots (in units $\frac{1}{3000}$th of the disc) works out at 5·15 as compared with 5·33 in 1926 and 3·53 in 1925. The only apparent spotless day was March 25, but visibility on that day was very poor.

The work of correlating magnetic and solar phenomena is being carried on.

Unfortunately, the observations at the total solar eclipse of June 29 were completely marred by clouds. A report of the preparations made and the work attempted was published in the *Monthly Notices*, **87**, 9.

Preparations were made to observe the times of occultation of the stars ι Tauri, and B.D. + 21° 754, during the total lunar eclipse on December 8, but an overcast sky prevented any observations.

The transit of Mercury was observed under moderate conditions on November 10.

University of London, University College Observatory.
(Director, Professor L. N. G. Filon, F.R.S.)

The usual observational work of the Observatory as part of the teaching for final and higher degrees in Astronomy has been carried on as in previous years.

Preparations were started early in the year with a view to observing

the total solar eclipse on June 29, and an expedition to Yorkshire was undertaken, but cloud prevented any results being obtained, and in consequence no separate report of this expedition has been made. A second-hand 6-inch visual objective by Cooke was purchased and used in conjunction with the 5-inch 30-degree prism by Hilger as part of a new Littrow spectrograph which was constructed in the workshop. A 4·5-inch coronagraph, and a specially designed spring-driven cœlostat with an 8-inch mirror, were very kindly loaned by Messrs. Cooke, Troughton & Simms. The mirror of the cœlostat was polished and silvered on both sides, which were made nearly parallel, so that the error of tilt could be easily eliminated by means of an auto-colimating telescope. A number of experiments were made in order to test a new method, devised by Mr. Gregory, for adjusting the cœlostat. This method proved highly satisfactory on the eclipse expedition. It consisted in observing the pole star with a theodolite provided with a Bohnenberger eyepiece. The theodolite could then be directed towards the east (or west) point of the horizon, and pointing towards the mirror of the cœlostat, which could be placed exactly in the meridian, an observation by reflection being made on both sides of the mirror. The zero error of the hour circle was then noted, and finally the altitude of the polar axis of the cœlostat was adjusted by a second theodolite observation, the dip of the theodolite being made equal to the colatitude of the place of observation. The order of accuracy of the adjustment of the cœlostat, made in this way, was found to be less than 2 minutes of arc, and the time required to make the adjustment about 25 minutes. In fact, a few minutes' observation of the pole star during one of the rare intervals of visibility was adequate to give almost perfect adjustment on the morning of the eclipse.

The site selected for the eclipse expedition was on the estate of Sir Frederick Millbank, near Barningham, Yorks., lat. 54° 28′ 8″, long. $7^{m}\ 30^{s}\cdot3$ W. The party, which consisted of the Director, Mr. Gregory, Miss Williamson, Mr. Harris, and Mr. Baserga as mechanical assistant, received the greatest kindness and hospitality from Sir Frederick and Lady Millbank. A contribution towards the cost of apparatus was received from the Dixon Research Fund of the University of London. Tents and camp equipment were kindly lent by the University of London contingent of the Officers' Training Corps. A storage battery to give 4 ampères at 200 volts was lent jointly by the Departments of Engineering and Physics of University College, in order that the iron arc might be used to give a comparison spectrum for the coronal and flash spectra. This, together with the instruments and camp equipment, were transported to Yorkshire by road. Plates were exposed, but no results were obtained owing to clouds at the time of totality.

A new line of research has been commenced with the Rowland grating, namely, the comparison of absorption band-spectra obtained in an electrical furnace at 1000° C. with the solar spectrum.

Dominion Observatory, Ottawa, Canada.
(Director, R. Meldrum Stewart.)

Meridian Work and Time-Service.—The programme of fundamental observations instituted in 1923 was continued, and 2676 observations of stars, 50 of planets, and 93 of the Sun were obtained on 172 observing days. Computations of the 1926 international longitude work have been practically completed, and the results are being prepared for publication. A new underground clock-vault was built, giving accommodation for four clocks. Work on the installation of temperature control and other fittings is under way.

The time-service has been maintained as in previous years without material change, and comprises 625 dials, 2 tower clocks, 4 primary clocks, 15 secondary clocks, and various relays, chronographs and seismograph shutters.

Wireless time-signals were received regularly from Annapolis, Lafayette, and Nauen, those from Annapolis and Lafayette being latterly recorded chronographically as well as by the extinction coincidence method of comparison. Mean Time signals are now transmitted daily except Sundays through the Ottawa radio station C.N.R.O. at 3 p.m.

Solar Physics.—About 550 nine-strip spectrograms of observations of the Sun and comparisons were secured, including a good series early in June, at λ 5600, for solar rotation; more than 400 measurements of spectra were made and computed. An examination of fur records of the Hudson's Bay Company revealed a striking relationship to Sun-spot variations. Somewhat over 150 direct photographs of the Sun were made, and prints were supplied to the Canadian Government radio branch for investigation of the connection between radio phenomena and Sun-spots. Plans were made for an instrument for mechanically showing heliographic positions of spots or other observed points on solar photographs.

The 15-Inch Equatorial.—Radial velocity work was continued on bright cepheids, some spectroscopic triple systems, and on σ Scorpii; in all 431 spectrograms were obtained. Evidence was found tending to show that ζ Geminorum and δ Cephei are triple systems or act as such. Evidence was also found indicating that ν Eridani, a remarkable β Canis Majoris type star, is apparently subject to strong tidal distortions. The photo-electric photometer, mentioned in last year's report, was put into operation and 61 observations of η Aquilæ and δ Cephei were made. Investigation of the variation of ionisation in cepheid variables was undertaken in collaboration with McGill University.

Photographic Photometry.—The co-operative programme in photographing cepheid fields for determination of the magnitudes of comparison stars was continued. The observational work was nearly completed, about 300 plates having been secured during the year. The measurement and reduction of plates was kept well under way. In the photography of cepheid fields for the determination of light curves about 300 plates were also secured, each group of cepheids being photographed over a period of two months. Some 19 cepheids were included

in the programme for the year, the magnitudes varying from 6·0 to 12·6, and the largest field covered being 12° by 14°.

Seismology.—During the year 349 earthquakes were registered, of which 23 were reported to the press, and 20 by telegraph to Science Service, Washington. The epicentres were, in general, difficult to determine from the records. The outstanding disturbances were: Japan, March 7; Chili, April 14; Kansu, May 22; Alaska, October 24; California, November 4; Kamchatka (?), December 28. Short-period Wood-Anderson instruments were installed at two points in the Province of Quebec, for investigation of local disturbances, though some details remain to be arranged before routine conditions are attained. The station at Ste. Anne de la Pocatiere has been discontinued; the instruments at Ottawa, Saskatoon, and Halifax were in regular operation throughout the year.

Terrestrial Magnetism.—Observations for secular change were continued. Declination, inclination, and horizontal intensity were observed at 56 repeat stations and 16 new points. The area covered is included between longitudes 78° W. and 131° W., and the Canada-United States boundary and latitude 56° N.

Gravity.—Gravity determinations were made at 6 stations in Ontario, 3 in Manitoba, 3 in Saskatchewan, and 3 in British Columbia. The results of gravity observations at 69 points throughout Western Canada were reduced and prepared for publication.

Publications.—Three publications were issued during the year, vol. 7, No. 3, *The Location of Epicentres*, 1922; vol. 8, No. 8, *Magnetic Results*, 1921-1923; vol. 9, No. 4, *The Spectroscopic System Nu Eridani.*

Dominion Astrophysical Observatory, Victoria, B.C.
(Director, Dr. J. S. Plaskett, F.R.S.)

The permanent staff of the Observatory has been increased by the addition of Dr. Carlyle S. Beals, while Mr. R. M. Petrie and Mr. P. M. Millman were temporarily employed as undergraduate assistants during the summer. Dr. H. Zanstra also spent three months at the Observatory in the summer making objective spectra of planetary nebulæ for spectrophotometric investigation.

The weather during the year has been decidedly unfavourable, as only 1197 spectra were secured in 1044 hours on 185 nights as compared with the nine-year average of 1637 spectra in 1244 hours on 203 nights. On 109 nights five or more spectra were obtained with a total of 1045, while on 76 nights less than five spectra were obtained with a total of 152. A total of 1358 star spectra were measured for radial velocity and other purposes during the year, and as a result the radial velocities of 275 stars and the orbits of 15 spectroscopic binaries were obtained. As in previous years two hours of the time of the telescope are given to visitors every Saturday evening, a privilege fully used, especially in the tourist season. Including day visitors also, it is estimated that 30,000 people visited the observatory during 1927.

Researches.—The director has continued observations of the B-type

stars as in the past three years, and it is estimated that next season should see the completion of this observing programme. Most of these spectra are measured, and in all, the velocities of 280 of the fainter B stars have been completed, of which Mr. Pearce is responsible for 112. The orbit of H.D. 193536 was completed and a correction to the orbit of 56°·2617 previously obtained was carried through. A spectrophotometric determination of the continuous spectrum of U Sagittarii, whose curious complex spectrum was investigated last year, indicates that the metallic and not the helium spectrum of this star is the fundamental one. A careful measurement of the wave-lengths of about 300 lines in this spectrum was also made. Perhaps the most interesting investigation of the year was an analysis of the radial velocities of all the B- and O-type stars determined here as a test for the hypothesis of a galactic rotation as advanced by Lindblad and previously tested by Oort. The material here was much more complete and homogeneous than that of Oort, and the distribution of the velocities of some 550 B- and O-type stars strongly confirm the existence of a rotation of the sidereal system in the galactic plane around a distant centre in longitude 325°.

Mr. W. E. Harper has continued the investigation of the A-type stars in the H.R. programme for spectroscopic parallax, and there have been secured altogether spectra of 858 A-type stars, of which 222 have measured parallaxes. Considerable investigation on the width and intensities of the spectral lines and other factors in stars of known parallax as possible criteria for obtaining absolute magnitudes has been carried through, and it is hoped soon to determine the absolute magnitude of about 1000 A-type stars. In addition, the radial velocities of 95 of these stars have been determined in the year, and the orbits of 5 binaries, Lal 4268, H.R. 5472, H.R. 839, H.R. 8210, and Boss 809, have been obtained.

Mr. H. H. Plaskett has completed and prepared for publication a full discussion of the stellar and the nebular parts of the peculiar composite spectrum of Z Andromedæ. The wave-lengths of the lines and their origin, the differences in velocities, the diameter of the nebulæ, and the colour temperature of the star were determined, while the physical meaning of these facts and the nature of the star were discussed. A complete table of all observational data on the emission nebulæ, including a discussion of the total and surface magnitudes, the character of the spectra and other data, was drawn up and an attempted correlation of the various factors begun.

Mr. J. A. Pearce continued the observation and measurement of the spectra of Class B stars in collaboration with the director, having obtained during the year the velocities of 45 stars, and altogether of 112 B and O stars. The orbits of two spectroscopic binaries, H.D. 57103 and H.D. 176853, were completed, while the orbits of four more are well under way. An investigation of the secondary component in the spectra of 12 B-class binaries with previously published orbits is in progress. Computations were made and graphs drawn to facilitate transformation from equatorial to galactic co-ordinates, and the determination of the distance and position angle of any star from the solar apex.

Dr. C. S. Beals has measured the wave-lengths of oxygen and nitrogen lines between λ3800 and λ4700 on third order grating plates for standards in stellar radial velocity work. The plates utilised were taken at the Imperial College of Science, South Kensington. Dr. Beals is also investigating the molecular spectrum of silver between λ3280 and λ3576, and has been able to fit the lines with the usual parabolic band formula and so determine the moment of inertia of the molecule, with the hope that the nature of the molecule and the distance apart of the atomic nuclei may be determined.

Mr. S. N. Hill has measured some 80 B-type spectra for radial velocity, with some additional work on spectroscopic binaries. He has computed the precessional corrections to the proper motions with the total proper motions and their position angles for the stars of the B-type programme, and has collaborated with Mr. Pearce in some of the computing, and has drawn the graphs for the galactic co-ordinates and for the position angle and distance to the apex for any star.

Mr. W. H. Christie, although not employed here during the year, has completed the discussion of the spectroscopic and photometric observations of 12 Lacertæ, showing that the periods are identical and correlating the velocity and light variation. He has advanced an explanation of the phenomena of this star as well as completing the orbit of H.R. 5702.

Mr. R. M. Petrie, employed for five months in the summer, has completed the orbits of two spectroscopic binaries, H.R. 6611 and H.R. 6979, and the radial velocities of 50 stars, which will appear shortly in the observatory publications.

Mr. P. M. Millman, employed for four months, measured 187 spectra, mostly of spectroscopic binaries, and has completed the orbit of H.D. 176819.

Dr. R. K. Young has completed the orbits of three long-period binaries, 4 Urs. Min., B.D. 66°878, and β Scuti, from observations made before his departure.

Publications.—There have appeared and been distributed vol. 3, Nos. 13 to 18 inclusive, with title-page and index, and vol. 4, Nos. 1 to 3, while in press and preparation are vol. 4, Nos. 4 to 9. In addition, several articles in astronomical periodicals by various members of the staff have appeared.

Helwan Observatory, Ministry of Public Works, Egypt.
(*Director, Mr. P. A. Curry.*)

Time-Service.—The time-service was maintained as usual, transits being taken on 43 nights from January 1 to June 20. From that date transits have been discontinued, the error of the Standard Clock Shortt No. 1 being determined from the Bordeaux rhythmic time-signals. The Shortt clock has run throughout the year without any attention, its rate being very good. No attempt is made to control the temperature, the losing rate being steady from January to March, then increasing gradually until August, after which it remained steady until November

when it began to decrease. The greatest change of rate in any month was 0·07 second. It is hoped to obtain a new reversible transit, when time observations will be continued.

Reynolds Reflector.—The telescope was used on 99 nights during the year; 106 plates were exposed, 60 plates on 49 nebulæ, and 39 plates in searching for comets. Comet Grigg-Skjellerup was detected on plates taken on March 23, 24.

General.—The usual meteorological, magnetic, seismological, and solar radiation observations were made.

Publications.—Bulletin No. 33 on the observation of wireless signals during 1926 October and November is now in the press and will be distributed shortly.

Kodaikánal Observatory.
(*Director, T. Royds, D.Sc.*)

1. Photoheliograms were obtained on 336 days, calcium flocculi plates on 333 days, calcium prominence plates on 294 days, and Hα flocculi plates on 328 days. During the year a total of 2533 spectroheliograms were obtained. One calcium flocculi plate for each day was sent to the Solar Physics Observatory, Cambridge, England, as in former years. Under the auspices of the International Astronomical Union prominence and Hα spectroheliograms were collected from other observatories whenever complete observations were not possible at Kodaikánal, and the combined results were published in the half-yearly bulletins. The Director has reported to the International Astronomical Union the desirability of further co-operation for more complete prominence data.

2. The modification of the Hα spectroheliograph, as mentioned in the last report, has been carried out. The replacement of the fixed feet of the spectroheliograph by movable bases was carried out without the loss of a single day's observations. The necessary remodelling of the Hα spectroheliograph using the same optical parts involved the loss of six days' record of Hα plates. By replacing all wooden structures by metal, not only has greater stability been secured but also the weight has been reduced.

3. A newly designed holder of the occulting disc for prominence spectroheliograms has proved invaluable for the photography of rapidly changing prominences by enabling the position of the disc to be changed instantaneously.

4. Some progress has been made on the review of prominence activity. Mr. P. R. Chidambara Aiyar has found that the variation in prominence areas is due more to a variation in the extent of base than in the height of prominences. Details of this will be included in the review.

5. A daylight comet of extraordinary brilliance was seen near the Sun from December 15 to 18. The identity of the comet is yet uncertain. The Director was absent from Kodaikánal at this time, and the observations were made by Mr. P. R. Chidambara Aiyar, who has prepared a bulletin giving details.

Nizamiah Observatory, Hyderabad.
(Director, Mr. T. P. Bhaskaran, M.A.)

Astrograph.—The programme of work with the astrographic equatorial remained the same as in the previous years. One hundred and three photographs were taken with the telescope, mainly for the determination of proper motions by comparison with the plates of the earlier series. Almost all the plates have been given a graduated series of five exposures in order to derive improved values of photographic magnitudes. Fifty-one plates were measured for proper motion during the year and the preliminary reductions have been carried on up to date.

The printing of vol. vi. (Zone $-22°$) of the *Hyderabad Astrographic Catalogue* has been completed. The MS. for vol. vii. (Dec. $-23°$) is ready up to R.A. 7^h; the printing of this volume will shortly be taken in hand.

The Grubb 15-Inch Telescope.—Regular observations of variable stars (mostly with very faint minima) have been continued. The working list includes 61 long period and 8 irregular variables, and 1504 estimates of magnitude were made during the year. The observations of 28 stars, which are in the list of the B.A.A. variable star section, have been copied and sent to the Association.

The weather conditions during 1927 were more unfavourable than the average, and very few nights were available for work from June to November.

Miscellaneous Observations.—Thirty-nine occultations of stars and planets by the Moon were observed:—

Disappearances	34
Reappearances	5

Comet Pons-Winnecke was observed on two nights in a hazy sky.

Transit Instrument.—Observations with this instrument have been continued as usual for determining clock corrections.

Seismology.—116 earthquake shocks were registered by the Milne-Shaw seismograph during the year, and monsoon microseisms were distinctly present in the records for 36 days. The readings of the seismograms to the end of 1926 June have been forwarded to the University Observatory, Oxford.

The meteorological observations and other routine duties have been carried on as usual.

Union Observatory, Johannesburg.
(Union Astronomer, Dr. R. T. A. Innes.)

During the year, joint colloquia of the staffs of the Yale Southern Station and the Union Observatory were held on twenty-five occasions (eighteen at the Union Observatory and seven at the Yale Telescope, the latter with Dr. Alden in the Chair). Amongst the visitors to these were Dr. Rossiter from Bloemfontein, Dr. Spencer Jones from Capetown, Mr. Ensor from Pretoria, and Dr. Moir.

26½-Inch Grubb Visual Refractor.—This instrument has been in continual use throughout the year. In November it was found that the rails on which the dome rotates had in part perished, and for four weeks the dome could not be moved; it was, however, left with the opening on the south meridian, so that the double-star surveys were hardly affected. Observations of the satellites Enceladus and Mimas of Saturn were made for Professor Georg Struve by Dr. van den Bos and Mr. Finsen. One hundred measures have been obtained. The double-star programme was relentlessly pursued. The work may be summarised as follows:—

2361 measures of double-stars,
503 new pairs discovered.

Estimates were only made on a few occasions when the driving clock failed; the clock is so placed that even simple repairs have to be made in the daylight. It is much better to have the driving clock exposed on the floor or thereabouts. The separating power of the telescope continues to give complete satisfaction, but it is not often that definition is perfect compared with the experience with the 9-inch. Every increase in aperture renders a telescope more susceptible to bad seeing.

On a few nights sweeps over the region of the Large Magellanic Cloud were made. The results have appeared in Circular No. 73.

Occultations of Stars.—The programme of the last few years has been maintained. In addition, amateurs are assisting. A number of observations by Dr. Moir, Auckland Park, Johannesburg, have been worked up here, and the results forwarded to Professor E. W. Brown; they agree well with those obtained here. It is hoped that by next year results from other amateurs will be received. The occultation results since the introduction of Brown's Tables, roughly grouped, give the following results, the first value giving the time the moon arrives too early at any longitude, the second the distance the moon is ahead of its predicted position:—

	s	″
1927·1	12·9	7·1
27·3	13·1	7·2
27·6	12·6	6·9
27·8	11·8	6·5

Throughout the year, time has been taken from the Bordeaux signals at 8^h G.M.T., corrected according to the provisional correction telegraphed the following day. The African Broadcasting Company broadcast the Union Observatory time automatically from Johannesburg on weekdays at 13^h, 17^h, and 20^h S.A. Standard Time. The company at first had some difficulty with the apparatus, but for some time past the accuracy of the signals has been satisfactory. Allowing that the accuracy of these results is limited by the necessarily weak star-places used, it is still apparent that the maximum time-error of the Moon in longitude was reached in 1924, and that it is now decreasing. The conclusions from the recent Transit of Mercury also indicate that the time-error is decreasing. Unfortunately the morning of November 10 was cloudy, and Mercury was seen only a few moments before egress,

so that no observations were obtained. Some results kindly communicated, and others published in the journals, have been worked up and will appear in Circular No. 75. The diminution from 1924 May to 1927 November is 4·3 secs., the occultations give 4·5 secs.

9-Inch Grubb Refractor.—This telescope has been in constant use for occultations, eclipses of Jupiter's satellites, comets, and measures of the wider double-stars, and on one night a week for visitors.

Franklin-Adams Star-Camera.—During the year 306 plates were obtained with this instrument. The distribution of the plates was as follows :—

Minor planets and star maps	83 plates
Variable star regions	69 ,,
Comets	146 ,,
Miscellaneous	8 ,,

The comet plates include a long series of short-exposure photographs of Pons-Winnecke's Comet at the time of its near approach. With the 6-inch guiding telescope attached to the star-camera, the following visual observations were made :

49 occultations of stars by the Moon
20 eclipses of Jupiter's satellites

to 1927 December 28 inclusive.

Comet Pons-Winnecke.—A series of observations of this comet was made here from June 24 to December 12, and an intensive campaign was carried out over the time of nearest approach to the Earth. These observations, both photographic and visual, are now being reduced. It is worth while remarking that upon the night of nearest approach the definition was very fine, and in the 26½-inch the nucleus was absolutely stellar and not in any way different in aspect from those of the numerous stars it quickly moved past. As an elongation of 0″·15 would have been seen, it may be said its diameter did not surpass that figure, which means that the larger limit for the diameter was about 2¾ miles, whilst the real diameter might be very much smaller.

Skjellerup's Bright Comet.—The news of this discovery reached here on December 6, but clouds prevented observation of it until December 8. The comet was very badly placed for good work, but from the communicated positions of the comet and two obtained here, a rough orbit was computed and cabled to Copenhagen.

Union Observatory Circulars.—During the year, Circulars Nos. 71 to 73 were issued, and the MSS. of Circulars Nos. 74, 75, and 76 are in the hands of the Government printer. These contain, in addition to the results of the routine work on comets, minor planets, occultations, Jupiter's satellites, etc., in No. 73 a further list of proper motions of stars on the Melbourne plates of the Large Cloud and partial descriptions of the clusters in it ; in No. 74, a 6-hour empirical ephemeris of Comet Pons-Winnecke over the period of its close approach to the Earth, and a discussion of the observations of the Transit of Mercury on November 10.

Southern Star Maps.—During the year, 27 of these maps were issued. The present state of this project is therefore :—

Maps already issued	266
Maps in Government printer's hands	28
Maps still to be prepared	262
Total	556

Loose-leaf Catalogue of Southern Double-Stars.—The issue of this work was completed in 1927 December, and hardly calls for additional comment. It is to be regretted that only about one-half of the region covered by the catalogue has been surveyed with the 26½-inch refractor, but the end is in sight.

The issue of this report coincides with the retirement of the present Union Astronomer. He is succeeded as from January 1 by Mr. H. E. Wood, M.Sc., F.R.A.S., who for many years has been his enthusiastic co-worker—to him and the other members of the Staff, the writer puts on record his grateful thanks.

Adelaide Observatory, 1926–1927.
(*Director, Mr. G. F. Dodwell, Government Astronomer.*)

The usual routine work of the Observatory, as described in previous reports, was continued during the years 1926 and 1927. At the end of 1926 observations of the International Longitude Signals by wireless were made by Messrs. A. L. Dawson, B.Sc., and A. E. Markey; the Director, through absence in England, was unable to participate in this work. During 1927 attention was given to magnetic observations on Yorke's Peninsula, where pronounced local disturbances of magnetism exist.

Mr. A. F. Bennett's Observatory, Leiston, Suffolk.

Observations of the prominences, for the solar section of the B.A.A., have been continued during the year, but have been somewhat hindered by the adverse weather conditions.

Early in the year two cameras, each provided with a Watson " Aviation " lens of 19·5 inches focus working at an aperture ratio of f5·8, were mounted on the 6-inch Cooke equatorial. They have been used for making simultaneous exposures on the fields of comets, minor planets, and other faint objects, for search purposes, and for determinations of place, in collaboration with the photographic and comet sections of the B.A.A. The lenses have proved very satisfactory for this work. A number of negatives were obtained of various objects, including comets Stearns (1927 *d*) and Pons-Winnecke, and Nova Aquilæ 60 (1927), and sent to Dr. Merton for measurement and reduction.

The 6-inch refractor has also been used for physical observations of these and other objects. The final phases of the Transit of Mercury on 1927 November 10 were well observed in clear weather.

The number of days on which the sky remained completely overcast exceeded considerably that for any year since the Observatory was set up in its present position six years ago.

Lee Observatory, Chorlton-cum-Hardy, Manchester.
(*Mr. A. A. Buss.*)

The year under review, the general deficiency in sunshine notwithstanding, offered just over 200 different dates, and the observational harvest is fully that of any previous year. Considering the loss of quite ten dates when absence meant loss of observation, the year just past constitutes a record for Manchester's much abused climate.

As regards solar spots, these were numerous and in many instances of naked-eye dimensions. In many cases their inception showed an elliptical formation of small spots, the preceding and following sides of which concentrated into forming leader-spot and trailer-spot respectively, the intervening area as usual remaining spectroscopically the most active portion of the outbreak.

Some of the prominences and of the dark flocculi were of exceptional dimensions, one of the former on July 15 reaching an altitude of much over 200,000 miles, while one of the latter as seen in projection extended quite over one-quarter of the sun's diameter, showing pronounced deflection effects to the violet near its northern extremity, and to the red near its southern extremity. The number of instances where eruptive dark flocculi and bright prominences were seen on the disc was very great. An exceptional case of intensity of brightness of an eruptive prominence occurred on May 7, in which the white form could be readily seen directly by using the total reflecting position of the grating. On September 4 a still more intense display was observed, showing no less than nine brilliantly reversed lines between Hβ and Hγ, while the number of reversals from Hβ towards the red helium line at λ7065 were too numerous to be counted.

A remarkable feature of the fairly numerous groups of jet-prominences should be recorded, viz. that all the jets of a group appear to reach the same altitude, but in most cases the jets making up a bunch keep fairly well together. On July 30 a disc-eruption was witnessed in which the two D-lines showed fully as brilliantly reversed as Hα. On the 20th of the same month and the next following days, a striking case of rotation of spots was observed, small outlying spots performing orbits round the primary large spot in a clockwise direction in S.L. During the third week of September a double-spot pair appeared in low S.L., in general configuration almost identical with the well-known double pair photographed by Messrs. Deslandres and Ellerman in 1909 September, and recorded at Greenwich as Nos. 6722 and 6723. As regards spectroscopic activity the two cases were also identical. On February 1, before daybreak, pronounced indications were present of aurora borealis, probably in connection with the intense activity displayed by S.L. spot outbreaks and their rapid developments.

Wolsingham Observatory.
(Rev. T. E. Espin.)

The year 1927 has been the worst for astronomical work we have yet experienced. Clear nights have been few, and the definition rarely good. The work has been continued as heretofore. Few micrometrical measures of known double-stars have been made, and the telescopes have been mainly employed in the examination of stars in the selected zones for new double-stars. The results have been communicated to the Society.

Mr. A. M. Newbegin's Observatory, Sutton, Surrey.

Observations were only possible during the first seven months of the year owing to the removal of the Observatory to Worthing in the autumn.

The usual routine work was carried out on the prominences and sunspots. Fifty-four observations yielded a mean daily average of 17·54 prominences, very uniformly distributed, but with a slight preference for the northern hemisphere and the eastern limb.

Metallic activity was recorded on 29 occasions, 58·6 per cent. being on the east limb and 55·2 per cent. south of the equator. No very violent outburst was seen, but Classes 2 and 3 were more in evidence than in the previous year.

Drawings of sunspots were made on 53 days mainly for purposes of identification. They show a very striking preponderance for the southern hemisphere.

The telescope was dismantled on July 18 and sent to Messrs. Cooke, Troughton & Simms, York, for an overhaul and to have ball-bearings fitted to the upper end of the polar axis.

Delivery was made on December 7, and observations were resumed on the 29th of that month.

The position of the new Observatory is as follows :—

Lat. N. 50° 48′ 50″.
Long. W. 0^h 1^m 33^s.

Mr. B. M. Peek's Observatory, Herne, Kent.

Physical observations of the major planets have been continued, especially of Jupiter, the results being communicated to the Jupiter section of the B.A.A.

With the 12-inch reflector the programme of photometric observations of four Novæ and three U Geminid variables has been carried out as well as weather conditions have permitted, but an almost continuous spell of cloud greatly interfered with the continuity of the observations toward the end of the year.

With the astro-cameras photographs were obtained of comets Stearns

and Pons-Winnecke, and plates were exposed in search of Grigg-Skjellerup; Comets Comas Solà and Pons-Winnecke were also observed visually.

The 19½-inch F/5·8 Watson camera was dismounted and taken with the 3-inch O.G. to Leyburn in Yorkshire for the total solar eclipse of June 29, but unfortunately no observations were obtained owing to cloud.

The transit of Mercury was well observed, and the results have been communicated to the Society.

Twenty-one occultations of stars by the moon were observed, mostly with the 150 mm. refractor, the results of which will be published shortly.

The Rev. T. E. R. Phillips' Observatory, Headley Rectory, Epsom.

The usual work on planets, double stars, and variable stars has been continued.

A list of double-star measures made in 1926 and 1927 has been communicated to the Society.

Special attention has been given to Jupiter, of which the surface details presented features of great interest. In particular a series of small black spots appeared in association with the S. Temperate belt, and many of them exhibited very rapid motions. The S. Tropical Disturbance, the S. component of the S. Equatorial belt, and the Red Spot Hollow (except a portion of the *p* shoulder) remained invisible; but the Red Spot itself was prominent and certainly redder than at any other time during the last thirty years. There was another object closely resembling it though fainter, in the same latitude, while yet a third of somewhat similar appearance was observed during the latter part of the apparition.

It is noteworthy that in so bad a year the weather about the time of Jupiter's opposition should have produced so large a number of clear nights. Observations were obtained on twenty nights in September despite frequent rain by day, and an anticyclone at the beginning of October was marked by a spell of exceptionally fine seeing.

The 23rd Report of the Jupiter section of the B.A.A. was published in November.

Unfortunately clouds at Leyburn prevented observations of the Total Eclipse of the Sun on June 29. It had been intended to photograph the infra-red end of the spectrum by means of a Rowland grating (kindly lent by Mr. A. M. Newbegin) and a 6½-inch reflector. Clouds, too, rendered the lunar eclipse of December 8 invisible, but the transit of Mercury on November 10 was observed in a cloudless sky.

The rainfall for the year reached 43·44 inches—an amount exceeding all previous records. The most striking meteorological occurrence of the year was the great snowstorm of December 25–26 when the roads were completely blocked by drifts.

Dr. W. H. Steavenson's Observatory, West Norwood.

The usual photometric observations of faint novæ have been continued with the 6-inch refractor, and also, by permission of the Astronomer Royal, with the 28-inch Equatorial of the Royal Observatory. The results of this work for the period 1926–1927 have been communicated to the Society.

Physical observations of comets Comas Solà, Grigg-Skjellerup, Pons-Winnecke, and Stearns were made with the 28-inch and 6-inch telescopes. Seen in the former telescope, the nucleus of comet Pons-Winnecke appeared to be less than one second of arc in diameter on June 19.

The total solar eclipse of June 29 was observed under good conditions at Giggleswick, and photographs of the flash spectrum were secured at second and third contacts. The lower corona was seen in a 3-inch telescope for three minutes and five seconds after the end of totality.

Between August 11 and August 23 some attempts were made near the summit of the Gornergrat (10,289 feet) to photograph the solar corona in full sunshine. A single lens of 7 feet focal length, fed by an unsilvered cœlostat, was employed, and work was confined to the red end of the spectrum, between $\lambda 5000$ and $\lambda 7000$. The weather was, on the whole, very unfavourable, and only one day yielded a really transparent sky. On this day (August 14) a photograph was secured which appears to show true coronal structure. Unfortunately, however, the sky became overcast before it was possible to make a second exposure. The result cannot, therefore, be regarded as conclusive. On the other hand there seems good ground for belief that, with some modifications, the methods employed hold out a fair prospect of ultimate success, and further experiments may be made at some future date.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1927.

Ninety-three planets were discovered in 1927, as follows :—

Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.
Jan.				Feb.				Aug.				Oct.			
AA	10	12·4	S2	DB	23	13·5	R	QC	30	14·0	R	TA	3	16	W1
BB	28	15·5	W1	DC	23	13·7	D	QD	29	13·6	B2I	TB	3	13·9	R
BC	28	12·5	W1	DD	25	13·3	N	QF	30	13·8	R	TC	3	13·7	W1
BD	23	13·0	O	Mar.				QG	30	14	R	TD	3	14	R
BE	26	12·5	O	EA	3	13·6	R	QH	30	13·6	R	TE	4	14	R
BF	26	13	O	FA	21	14	R	QJ	31	14	R	TF	3	13·0	D
BG	26	13·5	O	Apr.				QK	25	13·2	B2	TG	3	14·0	S1
BH	26	13·5	O	HA	22	13·6	R	QL*	25	13·0	B2I	TH	3	13·3	D
Feb.				HB	30	15·3	B1					UA	26	14	R
CA	7	16	W1	HC	30	16·0	B1	Sept.				UB	26	13·9	R
CB	7	13·8	R	HD	30	15·5	B1	RA	1	13·0	R	UC	28	13·3	R
CC	8	15	W1	May				RB	1	13·7	R	UD	29	14	R
CD	8	16	W1	JA	3	14	R	RC	1	15·5	W1	UE	29	13·5	R
CE	8	14	R	JB	1	12·5	A	RD	1	13·2	R	UF	29	13·7	R
CF	8	14	R	JC	1	13·5	A	SA	26	15·5	W1	UG	29	14·0	B2
CG	8	14	R	JD	1	13·4	A	SB	28	14·5	W1	UH	29	14·0	B2
CH	9	13·5	R	KA	24	12·5	S2	SC	28	14	R	UJ	29	13·5	B2
CJ	10	14	R	June				SD	17	12·0	D	UK	29	13·2	B2
CK	10	14	R	LA	1	13·7	R	SE	24	14	N	UL	29	13·5	B2
CL	10	14	R	MA	29	14·0	R	SF	24	13·5	N	Nov.			
CM	10	14	R	July				SG	25	13·7	N	VA	1	14	N, I
CN	10	14	R	OA	30	13·8	R	SH	25	13·5	N	VB	1	13·7	N, I
CO	10	14	R	Aug.				SJ	25	13·3	N	VC	1	13·9	N, I
CQ	11	13·6	J	PA	3	13·2	R	SK	26	13·6	S1	Dec.			
CR	7	11·5	O	QA	29	14	R	SL	30	13·8	N	YA	29	14	W1
DA	23	16	W1	QB	29	13·6	R	SM	30	14·0	N	YB	30	13·2	R

The initials of discoverers stand for : A = W. Albitzky, Simeis ; B1 = W. Baade, Bergedorf ; B2 = S. Beljavsky, Simeis ; D = E. Delporte, Uccle ; I = N. Ivanov, Simeis ; J = B. Jekhowsky, Algiers ; N = G. Neujmin, Simeis ; O = O. Oikawa, Tokyo ; R = K. Rein-

muth, Königstuhl, Heidelberg; S1 = W. Scharonov, Simeis; S2 = J. Comas Solà, Fabra, Barcelona; W1 = M. Wolf, Königstuhl, Heidelberg.

The following identities have been established: 383 = 1925 QC, 396 = 1925 RH, 462 = 1927 CP, 463 = 1926 TC, 508 = 1926 KA, 608 probably = 1927 QE, 722 = 1926 GR, 748 = 1925 QG, 814 = 1927 BA, 972 = 1926 XC, 1927 DC possibly = 684.

The following planets have received permanent numbers: 1924 QD = 1925 NA = 1056, 1925 QB = 1057, 1925 MA = 1058, 1925 OA = 1059, 1925 PA = 1060, 1925 TB = 1061, 1925 TD = 1062, 1925 XA = 1063, 1926 PA = 1064, 1926 PD = 1065, 1926 RA = 1066, 1926 RG = 1067, 1926 RK = 1068, 1927 BC = 1069.

The following planets have been named: 717 *Wisibada*, 738 *Alagasta*, 743 *Eugenisis*, 745 *Mauritia*, 927 *Tuckia* (for Edward Tuck and his wife), 953 *Painleva*, 976 *Benjamina*, 977 *Philippa*, 998 *Bodea* (it was Bode's law that suggested the presence of a missing planet), 999 *Zachia* (for Baron von Zach, who founded the Society to search for the missing planet), 1013 *Tombecka*, 1017 *Jacqueline*.

The names of 998, 999 are in connection with the names *Piazzia*, *Gaussia*, *Olbersia* of the three planets 1000, 1001, 1002.

Planets AA, BD have interesting orbits; the following are for AA from *Ast. Nach.* 5513, using observations from Jan. 10 to Feb. 6 (by J. Comas Solà), for BD from *Tokyo Ast. Bull.*, No. 3 (Sept. 20), using observations for Jan. 23 to Feb. 7.

Planet.	AA.	BD.
T	1926 Sept. 19·681 U.T.	1927 Apr. 9·4662
ω	147° 12′ 23″·1	199° 10′ 4″
Ω	279° 30′ 7″·5	343° 5′ 10″
i	25° 29′ 31″·0	5° 59′ 59″
φ	16° 13′ 38″·0	62° 27′ 25″
Period	3·67946 years	34·809 years
q	1·71734	1·20825
Aph. Dist.	3·04939	20·114

BD travels out to Uranus, its orbit being of a cometary character. The small inclination renders it liable to close approaches to Jupiter.

1036 *Ganymede* was observed last year, and will be again in opposition on 1928 May 1, mag. 14·4, decl. −12°.

433 *Eros* will be in opposition on 1928 Aug. 27, mag. 11·0, decl. +5°. This will be the last opposition before the near approach in 1931 Jan., and Dr. Jackson suggests that the opportunity should be utilised for determining the mean wave-length of the light of Eros.

Ast. Nach. 5523 contains a computation of the perturbations of 50 minor planets by E. de la Villemarque, S.J., Zo Se Observatory.

Ast. Nach. 5538 contains an article on the absolute magnitudes of the minor planets by A. Klose. These distribute themselves along an error curve with maximum at $9^{m}\cdot17$. The last 100 planets have lowered this by $\frac{1}{8}$ mag. The planets for which g exceeds $8^{m}\cdot5$ are now mostly known. Of those about $g = 10^{m}\cdot0$ some 1500 probably remain

to be discovered. The nearer asteroids divide themselves into two groups, the larger-sized ones giving a maximum at $9^{m}\cdot0$, the smaller ones at $11^{m}\cdot2$. In the distant regions we only see the larger ones. The inner system has for its nucleus the family that Hirayama designated the Flora family.

Professor Leuschner writes that the Research Bureau on the Minor Planets, working under the I.A.U., is making good progress in its report on their orbits and perturbations. The older planets are naturally being first dealt with.

Addendum. Additional planets 1927 AB, AC, AD were discovered at Yerkes by Professor G. van Biesbroeck. 1927 YB is identical with 1924 RE and is numbered 1071. 931 has been named *Whittemora* for Professor Thos. Whittemore.

A. C. D. C.

Report on Comets in 1927.

As mentioned in the last annual report, two comets discovered in 1926 (Comas Solà and Neujmin) passed perihelion in 1927. The former was observed at least up to the summer of 1927, the latter up to March 9, its magnitude rising to about 12. Comet 1925 *a* (Shajn, Comas Solà) was observed till 1927 March, and 1926 VI. (Giacobini-Zinner) was observed till March 4.

1927 *a* was found by Mr. T. B. Blathwayt at Braamfontein near Johannesburg on January 13, almost exactly a year after his first cometary discovery. It was in high south declination; and observations, which were continued till April, were confined to the southern hemisphere. The comet at discovery was a diffused object of the ninth magnitude.

1927 *b* was discovered by Mr. W. Reid at Capetown on January 26, being his sixth cometary discovery. It was of magnitude 8 at discovery, and was observed up till April, when it had become very diffused and difficult to observe. As mentioned in the last report, it passed perihelion on 1926 December 30, so is reckoned as 1926 VII.

1927 *c* was the short-period comet Pons-Winnecke. It was detected by Professor G. van Biesbroeck on a plate taken on March 3, its magnitude being 16·0. It was subsequently found on a plate taken by him on February 27, and on one taken by Dr. G. Merton at Greenwich on February 25. The identity of the February 27 image is doubtful, the position as published being discordant. It slowly brightened, and rose to the fourth magnitude at the end of June, when it was easily visible to the naked eye, about equal to the Great Andromeda Nebula. Perihelion passage occurred June 21·07, half a day later than Mr. C. J. Merfield's prediction. Its distance from the Earth on June 27 was $3\frac{1}{2}$ million miles, which is the second closest cometary approach on record, the closest being that of Lexell's comet, 1770 July 1, distance $1\frac{1}{2}$ million miles. The nucleus of comet Pons-Winnecke was very small and stellar. M. Baldet at Meudon gave its diameter as under a kilometre, Professor Slipher at Flagstaff as about 2 miles. The comet was

Ref. No.	Year and Number of Comet.	Name.	T.	ω.	Ω.	*i*.
420	1896 I.	Perrine-Lamp	Jan. 31·78864	358° 22′ 14″	208° 51′ 19″	155° 44′ 53″
468	1906 III.	Holmes	Mar. 14·11259	14 18 21	331 40 25	20 49 3
..	1913 O	,,	July 12·92419	21 48 26	329 32 38	19 34 32
507	1913 IV.	Metcalf	Sept. 14·05383	117 42 2	157 25 12	143 21 56
509	1914 V.	Delavan	Oct. 26·266507	97 27 22	59 8 37	68 2 0
521	1916 II.	Neujmin	Mar. 11·312688	193 46 59	327 32 44	10 37 34
535	1919 IV.	Schaumasse	Oct. 20·39588	45 46 57	90 37 31	14 44 32
555	1925 *c*	Orkisz	Apr. 1·49100	36 10 10	318 3 37	100 1 0
..	1927 *j*	Schwassmann-Wachmann	May 10·9230	359 56 14	322 35 2	9 27 37
..	1927 *j*	,,	July 10·15	343 29 0	323 50 0	9 30 0
561	1925 *f*	Borrelly	Oct. 7·56305	352 25 23	77 2 57	30 30 40
562	1925 *g*	Brooks	Nov. 1·75663	195 40 50	177 25 6	5 33 8
572	1926 VII.	Reid	Dec. 30·676	225 5 29	108 50 58	83 39 41
572	1926 VII.	,,	Dec. 30·41640	224 25 52	108 40 40	83 40 16
573	1927 I.	Neujmin	Jan. 16·208	193 43 15	327 39 12	10 37 44
574	1927 II.	Blathwayt	Feb. 14·503	231 50 50	18 47 43	92 21 16
575	1927 III.	Comas Solà	Mar. 22·1618	38 27 13	65 37 7	13 45 43
576	1927 IV.	Stearns	Mar. 22·5420	11 5 59	214 36 24	87 35 29
577	1927 V.	Grigg-Skjellerup	May 10·245	355 2 22	215 32 2	17 29 18
578	1927 VI.	Gale	June 14·56894	209 50 37	67 5 7	11 36 44
579	1927 VII.	Pons-Winnecke	June 21·064	170 22 35	98 8 34	18 56 26
579	1927 VII.	,,	June 21·07630	170 25 6	98 7 19	18 55 42
580	1927 VIII.	Schaumasse	Oct. 1·43	46 3 38	90 34 33	14 43 10
581	1927 IX.	Skjellerup	Dec. 18·0081	46 9 40	76 25 12	85 27 12
..	1928	Encke	P Feb. 19·6984	184 55 43	334 33 56	12 31 53
..	1928	Holmes	P Mar. 24·06	21 48 30	329 45 32	19 34 3

Notes on the Orbits.

T is given in G.M.T. up to the end of 1924, in U.T. after that. The letter P in this column refers to predicted value.

The epochs of osculation are as follows: Holmes, 1906 August 21·0 G.M.T., and 1913 July 15·0 G.M.T.; Neujmin, 1916 April 10·0 G.M.T.; Borrelly, 1925 June 23·0 U.T.; Grigg-Skjellerup, 1926 December 11·0 U.T. The hyperbolic character of the orbit of 509 at the time of perihelion was established beyond doubt, but Professor van Biesbroeck shows that it was due to the perturbations of Jupiter and Saturn, and that the orbit was elliptical when the comet entered the planetary system. The elements of Neujmin in 1916 were deduced before the return of the comet in 1927, and are subject to slight modification when combined with the later elements. The year of perihelion is 1925 for Nos. 555 to 562 inclusive. The elements of

ef. No.	log q.	Period in Years or Eccentricity e in Hyperbolic Orbits.	Equinox.	Computer.	Reference.
20	9·766899	e 1·000647	1896·0	W. Hristoff	*V.J.S.*, **61**, 288.
68	0·326762	6·857331	1900·0	J. Polak	*A.N.*, **231**, 365.
..	0·369623	7·332721	1910·0	,,	*A.N.*, **231**, 366.
07	0·132298	13100	1913·0	H. Kloth	*V.J.S.*, **61**, 288.
09	0·043148	e 1·000162	1910·0	G. van Biesbroeck	*Y.O. Pub.*, v., Part 2.
21	0·127017	5·42823	1916·0	G. Neujmin	*Pulkovo Bull.*, x., 6.
35	0·067592	7·94114	1919·0	G. Merton	*M.N.*, **87**, 567.
55	0·04507	..	1925·0	J. Witkowski, K. Kordylewski	*Acta astron.*, (c), **1**, 14.
..	0·740375	16·35298	1927·0	A. C. D. Crommelin	*I.A.U. Circ.*, 183.
..	0·67679	17·283	1927·0	L. E. Cunningham	*Harvard p.c.*, **49**.
61	0·142426	6·88519	1926·0	A. Schaumasse	*Marseilles Circ.*, 1016
62	0·269883	6·913413	1925·0	D. J. Martinoff	*A.N.*, **231**, 192.
72	9·87818	..	1927·0	J. M. Vinter-Hansen	*I.A.U. Circ.*, 159.
72	9·875883	..	1927·0	H. E. Wood	*Observ.*, **50**, 328.
73	0·126461	5·42946	1925·0	G. Neujmin	*Pulkovo Bull.*, 98.
74	0·01518	..	1927·0	J. M. Vinter-Hansen	*I.A.U. Circ.*, 160.
75	0·248610	8·52776	1927·0	Mello e Simas	*A.N.*, **230**, 108.
76	0·565918	11800	1927·0	A. C. D. Crommelin	*I.A.U. Circ.*, 185.
77	9·950661	4·98722	1927·0	G. Merton	*Observ.*, **50**, 159.
78	0·083929	11·10719	1927·0	A. C. D. Crommelin	*M.N.*, **88**, 85.
79	0·016698	6·00953	1927·0	B. Strömgren	*I.A.U. Circ.*, 154.
79	0·016694	5·98668	1927·0	F. E. Seagrave	*MS.*
80	0·06829	7·9501	1927·0	G. Merton	*M.N.*, **87**, 567.
81	9·23651	..	1927·0	A. C. D. Crommelin	*I.A.U. Circ.*, 182.
..	9·522011	3·286436	1927·0	L. Matkiewicz	*A.N.*, **231**, 11.
..	0·369996	7·3460	1928·0	J. Polak	*A.N.*, **231**, 366.

Schwassmann-Wachmann are still very uncertain; perihelion may possibly have occurred in 1926. The reference number of 1926 VII. has been changed from 571 to 572, since Schwassmann-Wachmann almost certainly precedes this. T for Nos. 575, 576 is so nearly the same that the order may possibly be changed. The first orbit of 579 adopts Merfield's predicted period (slightly modified); the second orbit derives the period from the 1927 observations only; this period is, therefore, less reliable. T for 580 has been diminished by 0·11 from the predicted value to satisfy the observations. The elements of 581 need further correction; this has been postponed till a longer arc is available. In the 1928 orbit of Holmes the values of T, M, n as printed in *A.N.* are not consistent, but I am uncertain where the error lies. The value of T derived from M and n is March 25·307. The values for n, U are consistent, so the error is probably not in these.

Four recent comets, 572, 574, 576, 581, have inclinations close to 90°.

observed at Johannesburg up to December, so there is ample material for deducing a good orbit. The perturbations by the Earth must have been appreciable, and there will be large perturbations by Jupiter at the next aphelion passage.

1927 *d* was found by Dr. C. L. Stearns at Van Vleck Observatory, Wesleyan University, Middletown, Connecticut, on March 10. It was of the tenth magnitude, well-defined, with a tail 10′ long in P.A. 215°, and a nearly stellar nucleus. It passed perihelion on March 22, its least distance from the Sun being 3·68 units, a value that is exceeded only by 1925 *a*, the comet of 1729, 1914 III., and the lately discovered comet Schwassmann-Wachmann. It was very well observed, its magnitude on December 21 being 13 (Professor G. van Biesbroeck). H. Thiele deduced elliptical elements with a period of 9517 years from an arc of three weeks; this is supported by the elements below, which are deduced from a six-months arc.

1927 *e* is the periodic comet Grigg-Skjellerup. Allusion was made in the last report to Dr. G. Merton's work on this comet, which has since been published in *Memoirs*, **64**. He established the identity of 1902 II. (Grigg) with 1922 I. (Skjellerup), and his prediction of the date of perihelion in 1927 was only a tenth of a day too late. He was the first to detect images of the comet on plates exposed by Mr. F. J. Hargreaves at Kingswood, Surrey, on March 27. The discovery was confirmed by further plates on March 23 and 24 (Helwan), 28 (Kingswood), 30 (Pinotorinese), and 31 (Bergedorf and Pinotorinese). The comet passed within a fifth of a unit of the Earth on June 3, but remained a rather difficult object, being faint and diffused. It was observed up to July, being well placed for northern observers owing to its high declination. Its period is so close to five years that the conditions at successive returns nearly repeat themselves.

1927 *f* was discovered by Mr. W. F. Gale (the discoverer of 1894 II. and 1912 II.) at Sydney on June 7; it was of magnitude 8·0, and was detected with binoculars; it was observed during June at the Cape, Johannesburg and Algiers, in July, August and September at Johannesburg only (as far as is known). It was found to be periodic, with a period of about 11·1 years, and to have made a fairly close approach to Jupiter one revolution ago. The orbit was discussed in *M.N.* for 1927 November.

1927 *g* is the periodic comet Schaumasse, discovered in 1911, and observed again in 1919. MM. Fayet and Schaumasse predicted the date of perihelion as 1927 November 19; in this prediction they used only the observations of the 1919 apparition. Dr. G. Merton showed in *M.N.* for 1927 May that this prediction was probably six weeks too late; the result verified his revised value almost exactly. Professor G. van Biesbroeck found the comet at Yerkes Observatory on October 4, its magnitude being 12·0. Once the position was known he was able to identify its image on a plate taken on September 23.

A few more positions were subsequently obtained, but the comet was a difficult object, being only observable low in the east, just before dawn. No observations except those at Yerkes Observatory have come to hand. The recovery of the comet at this return was fortunate; as the next two returns will probably be still more unfavourable. The

period is just under eight years, so the comet's position at perihelion is drawing nearer to the Sun at each return. It is worth mentioning that the period is almost exactly two-thirds of Jupiter's, so the perturbations are repeated after three revolutions.

1927 *h* is Encke's periodic comet. Search ephemerides had been published in the *B.A.A. Handbook* for 1927, taking T 1928 February 19·4. Subsequently L. Matkiewicz published a more exact forecast with T 0·3 days later, which has been verified by the observations. Professor G. van Biesbroeck found the comet on November 13, its magnitude being 16·0. He subsequently found images on plates taken on October 19 and 20, magnitude 17. This comet has not been missed at a single return since 1819, this being the 37th observed apparition. Halley's comet, with 28 apparitions, is its nearest rival.

1927 *j* was a faint comet of magnitude 13 to 14, discovered photographically by Professor Schwassmann and Dr. Wachmann at Bergedorf on November 15; it had a distinct nucleus and a nearly circular coma some 2′ in diameter. It was a difficult object in December, but observations are to hand up to December 28 at Bergedorf and 29 at Yerkes. The orbit proved difficult, owing to the slow motion of the comet, and the values obtained for perihelion passage range from 1925 May to 1929 November. All the orbits indicate a large perihelion distance, and the two latest ones, each deduced from a 6-weeks arc, place perihelion passage in 1925. The comet appears to have the largest perihelion distance and the smallest eccentricity on record, also to have been discovered at the longest interval after perihelion. It is to be hoped that more observations will be obtained, as those at present to hand are insufficient to establish the orbit with great accuracy.

The great comet 1927 *k* had several independent discoverers; but the one whose name it bears is Mr. J. F. Skjellerup, who made the discovery at Oakleigh, near Melbourne, on the morning of December 4 (local). He was the first to determine the position with any accuracy, and to announce the discovery to the world. It is his fifth discovery, the other four having been made in South Africa. When he found the comet it was low in the south-east in the twilight, being of the third magnitude, with a bright nucleus and a tail 3° long; it was moving almost exactly towards the Sun. He noted that α Centauri lay midway between the comet and α Crucis. The first to observe it (as far as known) was Mr. C. O'Connell of Marton, New Zealand, who saw it on the morning of November 29 (local); the next was Mr. Thos. Knox, of Russell Street, Northcote, Victoria, on the morning of December 2 (local). He showed it to several people prior to Mr. Skjellerup's discovery; it was so bright that he was able to see it even after daylight. A policeman on night duty at Bendigo, Victoria, found it at about the same time as Mr. Knox. Mrs. K. Botes of Fraserburg, South Africa, also saw it on the morning of December 2, but some hours later, owing to the difference of longitude. Mr. J. Smethurst, of Broken Hill, New South Wales, a member of the B.A.A., made an independent discovery on the morning of December 5 (local); he at once telegraphed it to Sydney Observatory; he subsequently obtained some positions of the comet with a theodolite. Mr. Ross Fitchet found the comet on the

morning of December 5 at Grahamstown, South Africa, and showed it to Mr. Theodore Mackenzie, a member of the B.A.A., on the same day. Mr. R. A. M'Intosh of Ponsonby, Auckland, New Zealand, observed it on the evening of December 5, but I gather from his letter that he had heard of its previous discovery elsewhere. He obtained some fairly accurate positions. Mr. Maristany found it at La Plata on the evening of December 6; apparently he had not heard of its previous discovery. Mr. Chidambara Aiyar, Assistant at Kodaikánal Observatory, who was in charge at the time in the absence of Dr. Royds, independently found the comet in daylight, very near the Sun, on December 15. He had, evidently, not received the I.A.U. telegrams announcing the discovery. It was then much brighter than Venus, and it must have attained magnitude − 6 at the very least. It was also observed in daylight at many American observatories, and a daylight photograph (apparently taken in infra-red light) was secured at Flagstaff; the head and coma are shown very plainly, also the brighter part of the tail. Spectroscopic observations were also taken there, showing that the greater part of the light was reflected sunlight. A recession from the Earth of 60 miles per second was indicated. The time of this observation was not given, but the average recession between December 20 and 21, calculated from the elements given below, was $54\frac{1}{2}$ miles per second, which is in fair accord.

A drawing, made by Professor G. van Biesbroeck at Yerkes before sunrise on December 21, is reproduced in *Popular Astronomy* for January. It shows the nucleus placed eccentrically in the tail, and a bright fan on the sunward side of the nucleus, produced by the intersection of two paraboloid envelopes. The latter feature is also shown in Mr. M'Intosh's drawing of December 6; this shows also a dark, narrow stripe down the middle of the tail; the whole appearance closely resembles that of Coggia's comet of 1874 (Brodie's drawing, Chambers' *Story of the Comets*, p. 149). Professor C. Hoffmeister of Sonneberg observed a greater extension of the tail than any other observer. He saw it on the mornings of December 29, 30, 31, January 2 to a length of some 40°, extending to Hercules. Its breadth was 2°. The head was not seen, being too near the Sun (*B.Z.*, No. 2). The comet was nearest the Sun (distance about ·172 unit) on December 18. Its maximum distance north of the Sun was about 12°. Most of the observations to hand were made by reading the circles of equatorial telescopes, since no comparison stars were visible owing to the bright sky; hence they are much less exact than most cometary observations, and it is to be hoped that southern observers will follow it as long as possible, after it has left the Sun's neighbourhood, in order to improve the orbit. The elements Ω and i are very close to those of De Vico's comet 1846 IV., but ω and q differ too much to make identity possible. There is also a general resemblance to the orbit of 1860 III., not close enough for identity, but suggesting a possible common origin.

The table of elements contains J. Polak's predicted elements for the return of Holmes's comet in 1928; F. R. Cripps's value of T (*B.A.A. Handbook*, 1928) is March 22·63, which agrees with Polak's within the probable error. The conditions for observation in the summer

and autumn of 1928 will not be much worse than those of 1906, when the comet was observed; so it is to be hoped that it may be recovered.

It is worth pointing out how successful has been the search for periodic comets in recent years; fourteen of these have been observed on their return in the years 1924, 1925, 1926, 1927, and only one missed, that of Schorr, the conditions for this being very unfavourable. It is to be feared that equal energy is not shown in the search for unexpected comets, many of the comets discovered being swept up casually in the course of other work. This applies to northern observers only; there are active workers in the southern hemisphere.

So far as its orbit is concerned, it would seem that the object BD discovered by Mr. Oikawa on February 7 (see "Note on Minor Planets") had a right to be included among the comets; for its orbit is so eccentric that it goes from the orbit of Mars to that of Uranus. But the aspect was, apparently, quite stellar.

M. Chaput reported an object of cometary appearance near the Pleiades on January 29, but no confirmation was obtained.

A.N. 5504 contains an article by A. Markov on the brightness of comets; he recommends using extra-focal images of comparison stars, so as to get similarity of aspect with comets. He also estimates the mass of some comets by their light; his results are of the order 10^{-9} to 10^{-13}, in terms of the Earth's mass.

Two Memoirs on cometary spectra have appeared; one by Dr. H. A. Deslandres, in the Meudon Observatory *Publications*; the other, a thesis by M. Baldet, which contains a résumé of previous work on the subject. A. C. D. C.

Solar Activity in 1927.

Sun-spots.—Although in general the sun-spots and faculæ have been considerable, there has been a sudden halt in the rise of activity which was so marked a feature during 1925 and 1926. The provisional values of the mean daily area of spots, the average number of groups seen daily, and the frequency of faculæ, indicate that the solar activity for 1927 was rather less than that for the preceding year. There were, however, ten groups of spots large enough to be seen with the naked eye, but none of these was as large as the fourth in order of size for 1926. The dates of the central meridian passage and the latitude of these large spots for 1927 were as follows:—

Jan. 1·3	7° S.	July 5·4	15° N.
,, 8·5	13° S.	,, 27·8	8° S.
,, 19·3	25° N.	Aug. 14·2	10° S.
May 11·7	17° N.	Sept. 14·3	19° S.
June 8·0	16° N.	Nov. 10·4	9° S.

One of the largest of these groups, which was observed from May 9 to May 17, was still a naked-eye object when it crossed the Sun's central meridian for the third time on July 5. On June 29, at the time

of the total eclipse of the Sun, this spot was within a few degrees of longitude of the Sun's east limb, at position angle 75° from the north point of the Sun's axis.

It may be added that spots were more frequent during the first six months of the year, and that their average latitude for the twelve months was a little greater than 15°. Although it is possible that the peak of the present cycle has been passed, it seems more probable that it will occur during the coming year. H. W. N.

The Prominences.—The mean daily areas in square minutes of arc derived from Kodaikánal photographic records are as follows :—

	North.	South.	Total.
1927 January to June . . .	4·15	3·58	7·73
July to December . . .	3·03	2·47	5·50

The mean daily numbers were 19·4 and 19·7 for the first and second half years respectively. Compared with the year 1926, areas show a decrease of 15 per cent. and numbers a slight increase.

The maximum of prominence activity in high latitudes showed an advance of 10° towards the poles during the first half-year when compared with the second half of 1926, but during the second half of 1927 the activity in high latitudes almost subsided according to areas although still evident in numbers. In other respects the distribution in latitude was of a similar type to that of the second half of 1926.

Prominences exhibiting metallic lines numbered only 81, whereas 152 occurred in 1926. All occurred below latitude 50°. In several features, however, there was an increase in solar activity during 1927. The number of hydrogen displacements in prominences and in the chromosphere was 787 as against 650 in 1926, but 535 of them occurred in the first half of the year. Of the displacements, 456 were towards the red, 322 towards the violet, and 9 both ways simultaneously. The most remarkable displacement was in the eruptive prominence of March 14 mentioned below. Bright reversals of the Hα line in the neighbourhood of sun-spots numbered 803, as against 705 in 1926. Displacements of the Hα line on the disc totalled 308, an increase of over 40 per cent. on the previous year. Of these displacements, 220 were towards the red, 82 towards the violet, and 6 both ways simultaneously. D_3 was observed as a dark line on 643 occasions, as against 456 in 1926.

A remarkable eruptive prominence was observed on 1927 March 14. At $8^h\ 40^m$ a.m. I.S.T. and at $8^h\ 53^m$ no noteworthy prominences were visible on spectroheliograms, but by $9^h\ 18^m$ a large irregular prominence reaching to nearly 7′, or 300,000 km. above the chromosphere, had developed in the NE. quadrant. More remarkable still were the displacements in this prominence observed visually by Mr. S. Balasundaram Aiyar. The Hα line was displaced for a few minutes up to 20 A towards the red and 5 A towards the violet; in D_3 light the prominence was displaced as far as D_2. It seems therefore likely that the

true form of the prominence was not shown in the photographs, which record only the forms exhibited by the undisplaced line.

The mean daily area of prominences projected on the disc as absorption markings in hydrogen light was 3766 millionths of the Sun's visible disc, a reduction of over 20 per cent. on the year 1926. Their distribution in latitude was similar to that in 1926. T. R.

Solar Research in 1927.

Solar Radiation.—The problem of the variability of the solar radiation remains controversial. C. G. Abbot (1) has published tests of the variability of the sun by pyroheliometric measurements at Montezuma, and finds good agreement with solar constant determinations. Tables of monthly average values from 1918 to 1926 are given, and he notes a 26-month periodicity. Other evidences adduced by him for related solar and terrestrial changes are derived from ultra-violet radiation values, and long-range wireless signals, both of which are correlated with the solar constant. H. H. Clayton (2) has correlated atmospheric ozone content with solar radiation and sun-spot numbers. C. F. Marvin and H. H. Kimball (3) are of the opinion that the evidence for a variation of the solar radiation is submerged in the errors of determination of the solar constant. Abbot (4) has replied in detail to the criticism of his determination of the distribution of energy over the Sun's disc, and explains that the investigation was not pursued by him closer to the limb, because it was not required for a study of solar variation.

J. Stebbins (5) has made a photometric study of the light variations of the satellites of Jupiter, and suggests the use of his results to discuss solar variation. The accuracy of his determinations is good, and he estimates that a solar variation of 2 per cent. in a week should be detectable.

A review of the problem of solar energy has been published by D. H. Menzel (6).

Sun-spots, Faculæ, and Prominences.—J. Evershed (8) has examined the behaviour of and classified the H and K lines in prominences, and from the quiescent ones has measured the solar rotation and deduced a value for the Einstein shift. E. B. Knobel (9) suggests that the whiter colour of prominences observed at heights above the surface of the earth may be due to the elimination of the absorption by our atmosphere.

Velocities up to 6·5 km./sec. have been found for the motions of metallic vapours in sun-spots by G. Abetti (10), who confirms St. John's observation that the velocities decrease with increasing intensity of the lines.

A statistical study of sun-spot numbers by G. U. Yule (7) yields the conclusion that periodicities may be present which are modified by sudden changes of amplitude and phase, rather than undisturbed periods obscured by fortuitous errors.

Corona.—Photometric observations of the corona of 1925 January 24 by the late J. A. Parkhurst have been reduced and published by A. H. Farnsworth (16). The illumination produced by the corona is 0·27 that of the full moon, its candle-power being 0·04 metre candles, and that of the full moon 0·16.

Visual and photometric observations of the corona of 1926 January 14 in Sumatra by H. T. Stetson, W. W. Coblenz, W. Arnold, and W. A. Spurr (15) yield the results that the minimum illumination of corona and sky was 0·0128 metre candles, and the photographic observations yield (in a three-degree circle) a photographic magnitude of − 11·38 and a colour index of + 0·62, agreeing well with King's measurements in 1925. The coronal light was 40 per cent. greater at the 1926 eclipse, showing an apparent increase with sun-spot numbers. Radiometer measurements were rendered impossible by light clouds.

Professor Horn d' Arturo (17), in an account of the Italian expedition to E. Africa for the eclipse of 1926 January 14, compares the plates taken there with the ones taken in Sumatra and finds motions of the coronal domes and evidences of considerable changes in the interval between the exposures.

E. S. King and M. Harwood (18) found in their study of the distribution of light in the corona on 1925 January 24, that at points farther out than 10′·5 from the limb the inverse square law of brightness is obeyed.

Spectroscopic Work.—A formidable attack has been launched on the measurement of the shapes of the Fraunhofer lines. The problem bristles with difficulties, as can be seen at once from the papers of von Klüber (22) and Minnaert (23), and if the difficulties are so great when there is no shortage of light and powerful spectrographs can be employed, the outlook for stellar spectrophotometry seems indeed black; but fortunately the solution of some of the problems would be valid in both fields, and the solar work has the advantage of allowing of more searching investigations into the various sources of error. Both the papers quoted deal largely with the development of a suitable technique, and the general conclusion to be drawn seems to be that line shapes can be approximately described, and that total absorption in a line may be found with good approximation. It seems to be difficult to find an instrumental error that has the effect of making an absorption line too deep at *all* points, though the " development effect " could have the effect of deepening it at the centre. Possibly the best results could be obtained from an analysis of several spectra of different dispersion and resolving power, taken on different instruments. The microphotometers themselves appear to work with all the accuracy required at present. The actual forms of the intensity curves for a few solar lines are given by the above writers. Minnaert's curves are deeper and show more absorption than von Klüber's, and this is explained by Minnaert as due to the omission of certain corrections by the latter.

A considerable amount of work has been done in establishing identifications of the lines of certain rare elements in the solar spectrum.

Thus A. S. King and C. E. Moore (24) find evidence for the existence in the sun of PrII, NdII, and SaII; also they find CeII (26) and possibly CeIII (25), but not CeI (26).

A discussion of the existence of lines due to cadmium in the solar spectrum by C. E. St. John and C. E. Moore (27) is of interest for its use of modern methods and data of spectroscopy. They conclude that we should probably reject all identifications of solar lines with Cd lines except the ultimate line at 3261 A.U.

Accurate measurements of wave-lengths in the infra-red region of the solar spectrum between 6868 and 8980 A.U. have been made by H. D. Babcock (28), using plates sensitised with neocyanine. The diffuse doublet and satellite of CaII are included in his measures, and many telluric lines are registered.

J. Evershed (29) reports the discovery of an emission line in the solar spectrum near K. It is a faint narrow line found in spectra taken near the limb and cannot be due to calcium since there is no corresponding line near H.

C. R. Davidson (30) has photographed the chromospheric spectrum in the regions near H and K and the CaII diffuse lines by setting the slit of a spectroscope near the limb of the sun's image without an eclipse. The bright emission lines are compared with the adjoining continuous spectrum, and by means of an assumed temperature of 5000° the absolute intensity of $\lambda 8542$ is found to be somewhat greater than K at moderate levels.

Eclipses.—The full report of their results obtained in Sumatra at the total eclipse of 1926 January 14 has been published by C. R. Davidson and F. J. M. Stratton (31), with full details of the measurements of the wave-lengths in the excellent spectra obtained, and some of the photometric investigations. There is a very elaborate discussion in the light of the theory of multiplet intensities, and reproductions of the spectrograms secured and of the corona. The flash spectrum obtained with the quartz slit spectroscope extends to below 3100 A.U. in the ultra-violet, and most of the lines have been identified. Heights in the chromosphere have been estimated from the spectra obtained with the 19-foot prismatic camera. Many deviations from Mitchell's values for 1905 are found. A table is given of lines definitely considered to be coronal lines of unknown origin and of probable identifications of certain lines to be removed from the list of coronal lines. A preliminary account of the photometric investigations of the Balmer series, the continuous spectrum beyond it, and of the intensities in the coronal lines is given; the last named show some curious features whereby certain lines appear to be associated together in pairs.

It is rather too early to expect final reports from those who were sufficiently fortunate to get any detailed observations of the total eclipse of 1927 June 29, but a good many preliminary reports are published (32 . . . 43) and some of the simpler observations given. In England the Astronomer Royal's party at Giggleswick were for tunate, and a good photograph of the corona was obtained; spectra, and also aeroplane photographs of the eclipsed sun were taken.

R. L. Waterfield obtained photographs of the corona. Records of observations of the temperature change have been obtained by the National Physical Laboratory (32) expedition and by J. R. Ashworth (33). Observations of the darkening were obtained by W. J. S. Lockyer (35), who found the illumination much more intense than it is on a bright moonlight night, and by A. S. E. Ackerman and J. H. Shaxby (36), who found the illumination received by a horizontal surface exposed to the whole hemisphere of the sky. G. Armellini and G. Conti (37) at Ringebu in Norway found the illumination during totality greater than that of the full moon. These observers also give a sketch of the corona.

E. F. Carpenter (44), in a photometric study of the flash spectrum, utilises the spectra obtained with falling plate cameras. Unfortunately he has no proper photometric scale by which to reduce the observations, but they serve to emphasise the great value of the method in a study of the variation of intensity of chromospheric lines with height. He finds that the H and K lines are winged up to a height of 600 or 700 km. above the surface. From their spectra taken at the eclipse of 1926 January 14, C. R. Davidson and F. J. M. Stratton (48) identify and discuss certain multiplets of nickel and cobalt in the chromospheric spectrum. In a rediscussion of the identification of rare earths in the flash spectrum, D. H. Menzel (50) pleads for the acknowledgment of identifications with rather greater freedom than has been customary.

L. J. Comrie (45) describes calculations for certain problems arising in eclipse programmes. J. A. Carroll (49) gives estimates of probable exposures needed to photograph the infra-red CaII lines with neo-cyanine plates at eclipses.

Theoretical.—P. A. Taylor (51) has developed Milne's theory of the equilibrium of the calcium chromosphere to take into account the curvature of the sun's surface and the variation of gravity with distance from the centre of the sun. The results of this investigation are used (52) in a calculation of the intensity of the H and K radiations as observed in a telescope pointed near the limb of the sun in terms of the height above the limb of the point towards which the telescope is directed.

S. R. Pike (53) has investigated the motions of the gases in the chromosphere. He points out that local raising or lowering of the radiation by sun-spots or bright regions (faculæ) results in considerable lateral motions; the dynamical equilibrium is examined and the magnitudes of the currents possible discussed.

H. M. Losh (52) discusses whether planetary tidal forces may not produce sensible effects in the sun and generate sun-spots, for example, since the radiation pressure and gravitational forces may balance, but points out that the centrifugal force which is enormously greater does not produce any detectable effect.

Miscellaneous.—G. Blunck (57) has developed and tried with promising results a method of photographing the sun's surroundings without an eclipse. He uses specially sensitised plates which are most

sensitive in the region of 8500 A.U., and so works in a region where the contrast between the sky and the coronal background is sufficient to show on a photograph.

An illustrated description of Hale's spectrohelioscope is given by L. M'Crae (58), who points out the very considerable advantages such an instrument has over a spectroheliograph for certain purposes.

J. A. C.

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Sun-spots, Faculæ, and Prominences.

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Stellar Spectroscopy in 1927.

Photometry and Spectrophotometry.—The application of modern microphotometers to the study of stellar spectra has gone on apace, and from Harvard has been issued a most interesting series of papers reporting the results obtained there, and discussing the methods used. C. H. Payne and F. S. Hogg (1) have investigated the reduction curves, the sources of error, the effects of change in resolving power of the spectroscopes employed, and of using different plates, and have devised tests of accuracy. Miss Payne concludes (2), (3) that the visual scale of line intensities is useless for the intercomparison of different stars, and that under existing conditions widths and depths of lines as measured are not significant, but the area of the curve of absorption within a line is little affected by instrumental errors, and can be taken as a real measure of the total absorption by the stellar atmosphere. The same two observers find good agreement between line intensities deduced from objective prism spectra and slit spectra (4) when due allowance is made for the effects of different resolving power. Miss Payne has also studied the correlation between mean intensities of lines (in certain groups of lines) and luminosity. Among the special studies published, that of Mira (7) at the maximum of 1926–27 states that the emission lines of hydrogen contribute 0·1 of a magnitude to the photographic light of the star. The hydrogen lines decrease in strength with the decrease in brightness of the star, but not uniformly; there are slight rises, and one of these coincides with a slight break in the visual light curve. In a study of the brighter stars of the Pleiades (8), (9) the spectral variation of certain stars is substantiated, and the relation of absorption to emission lines is illustrated. Altogether the spectral energy curves, or rather the microphotometer curves, for nearly 100 stars have been published. In a discussion of stars near N.G.C. 6231 (14), it is concluded that it is improbable that the spectral energy curve can correspond on the very high temperature (40,000°) deduced spectroscopically for these stars. A discussion of the general

problem of spectrophotometry has also been made by A. Pannekoek (17), and measures with two different photometers are given by him. Reference should also be made to the spectrophotometric work on the solar spectrum, described in the note on Solar Research.

W. M. H. Greaves, C. Davidson, and E. Martin (18) have determined the relative effective temperatures of 22 stars of early type (B and A). These are some results of the method mentioned in the Council note last year and given in *M.N.*, **86**, 1925. The wave-length of maximum intensity in the spectra of these stars lies outside the range of spectrum accessible, and the temperatures are determined by comparison of the spectral energy curve with that for an A0 star, which is thus used as a kind of standard black body, and the temperatures are referred to assumed values for A0 as a standard. Thus the difficulty of determining atmospheric absorption is avoided. The results agree well with colour index data, but not so well with the results of Fowler and Milne based on line intensities. An interesting feature of the results is that the star ζ Persei is abnormally cool, *i.e.* red, for its type.

E. Pettit and S. B. Nicholson (19) have made a series of radiometric measurements of certain faint red stars, of type M (all but one fainter than 8th magnitude). They all have a large heat index, the most striking example being RS Virginis, with a H.I. of 6·1 and a visual magnitude of 9·8, and a star near the Trifid nebula of visual magnitude 13·7 with a H.I. of 7·0. This latter star is the only one not a long-period variable for which such a large heat index has been observed. It may be of interest to remind readers of the outstanding example of a star with a large H.I., namely χ Cygni, which is 11·9 magnitudes brighter bolometrically than it is visually.

Spectroscopic Binaries.—O. Struve (20), (21) describes an unusual spectroscopic binary in 27 Canis Majoris. The star appears to consist of four components with very large masses, the average mass of each component being at least 238 times that of the sun. The possibilities that the displacements of the lines are not due to velocity, and that there may be an error in the period are discussed and considered inadmissible, but in a later paper the author shows that there are no data to decide between three possible periods, two short ones and one long one. The long period, he remarks, gives improbable masses, but observations at a southern observatory could provide the data necessary to decide.

The spectroscopic binary β Doradus was found by D. Applegate (23) to have all the cepheid characteristics except for the light curve. There may, however, be some small light variation.

Evidence for the existence of stars in the dumb-bell stage of fission is adduced by J. Schilt (22) on the basis of the widths of the lines in their spectra and the fact that they do not show an eclipse of more than half a magnitude.

Spectroscopic Parallaxes.—Over 1000 spectroscopic parallaxes are published in three papers, each involving extensions and improvements in technique. W. S. Adams, A. H. Joy, and M. L. Humason (36) give

the absolute magnitudes and parallaxes of 410 M-type stars ; A. Woods (37) those of 300 Ao to A5 stars, using for standards the values in Schlesinger's catalogue with corrections in the manner suggested by Dyson in *M.N.*, **86**, 686 ; and D. L. Edwards (38) those of 300 B-type stars, using a modification of the method of Adams and Joy which is fully discussed by him. B. P. Gerasimovic (39) points out that the notable decrease in effective temperature of Be stars is not connected with a decrease in luminosity, but is rather a manifestation of high luminosity. Magnitudes of certain A stars have been determined by A. V. Douglas (40) using criteria relating to widths and relative intensities of lines. In determining the distance of N.G.C. 752, K. G. Malmquist (41) uses the mean apparent and absolute magnitudes of white giants, and then discusses the cluster.

C. S. Yü (42) in discussing Mitchell's critique of his method of determining absolute magnitudes of A stars does not agree that his method involves no third unknown, *i.e.* temperature, and shows that a rediscussion of Mitchell's tests leads to a reduction in the magnitude of both the systematic and accidental error, so that the method promises well.

Theory of Spectra and High-Temperature Ionisation.—Quite the most exciting event in the past year in astronomy has been the brilliant solution by I. S. Bowen (47) of the problem of the origin of the nebular lines, which has perplexed astrophysicists for more than half a century. Bowen pointed out that conditions in nebulæ may be expected to be especially favourable for the excitation of the so-called " forbidden lines " of spectra, and, using the results obtained by Millikan and himself on the extreme ultra-violet spectra of ionised oxygen and nitrogen, was able to identify most of the stronger nebular lines with forbidden lines in these spectra. A. Fowler (48) has investigated these spectra in the region of longer wave-lengths, as have also Croze and Minull, and not the least interesting feature of the new identifications is that the conditions in nebulæ allow transitions to occur and lines to be observed that provide the otherwise missing links between the spectral series which allow the term values to be accurately evaluated and more precise values to be assigned for the nebular lines. This was done by Fowler, and the result was to strengthen Bowen's suggestion, to add to the series classifications, and incidentally to suggest the possible existence of a hitherto unobserved nebular line. Bowen's remarkable ingenuity has stimulated further work, and in particular the problem was raised of why these particular lines are developed in nebulæ to the exclusion of the " normal " lines. This problem has been attacked by Woltjer (49) and by Eddington (50), who finds Woltjer's conditions not necessary, or rather not all relevant, and that the important requisite in addition to low density of the material (*i.e.* long free path) is that the stimulating radiation must be very weak. There seems to be no difficulty to be anticipated in accounting for the actual observed brightness of the nebulæ, though the necessary atomic data, so that precise calculations may be made, must be eagerly awaited. So the mysterious lines turn out in the end, we learn, to be due to

nothing more mysterious than oxygen and nitrogen, singly or doubly ionised, though acting in a rather mysterious way perhaps. It remains to be seen whether Coronium will yield a similar answer, though Eddington states that it seems unlikely in view of the absence of the requisite conditions, unless the metastability involved is of a very different order of magnitude. (See Solar Research.)

The theory of ionisation in stellar atmospheres has received attention from several investigators, and several refinements and improvements have been effected. C. H. Payne (52) has discussed the effect of changes of partial electron pressure and applied her results to the spectra and ionisation of *c* stars (*c*F8).

Classification.—Three peculiar spectra have been discussed by J. S. Plaskett (58). They are those of υ Sagittarii, HD 50820 and HD 45910. The spectra are similar, being complex and peculiar, consisting of B2 or B3 and A2 mixed. If the displacements of the lines are attributed to velocity in a binary system the masses obtained, as by Ludendorff for υ Sagittarii, are improbably large. Plaskett thinks that the lines arise in one star, and that the lines used by Ludendorff are not displaced by orbital motion but are components of a split line in the star.

P. W. Merrill (65) notes that in stars whose spectra contain bright iron lines, the lines due to the ionised atom are more frequent than those due to the neutral atom.

C. S. Yü (59) has studied the continuous ultra-violet emission spectra in Be stars and a probable continuous general absorption in the spectrum of P Cygni. He found from certain B stars examined that a surface temperature of a bright line star derived from the intensity distribution of the continuous background is in every case lower than the average effective temperature of its class. A new examination confirms this. He finds continuous hydrogen emission beyond the Balmer series (*e.g.* γ Cassiopeiæ), and examines the intensity distribution of the continuous emission spectrum. Two suggestions are made to account for the observations. (1) Electron captures, and (2) that the lines are bright only by contrast created by the absorption of the continuous background (P Cygni). He discusses the theoretical significance, and thinks that bright line stars may have a hydrogen envelope.

W. S. Adams, M. L. Humason, and A. H. Joy (60) have published some results obtained with spectroscopes of very high aperture ratio so that the spectra of very faint stars can be photographed. The spectra obtained are useful for classification and for rough determinations of radial velocity.

A. van Maanen (64) draws attention to a star of extremely low luminosity, which is our nearest known neighbour but two, with a parallax of $0''{\cdot}404$, photovisual magnitude 13·5, photographic magnitude 15·5, and hence absolute magnitudes 16·5 and 18·5 respectively. This star Wolf 359 is then the intrinsically faintest known star. Its spectrum is M6e and a radial velocity of $-$ 90 km./sec. has been found. It lies outside the range for spectroscopic magnitude determinations.

The changes in the spectrum of R Aquarii in 1920–26 are found by P. W. Merrill (63) to correspond in a general way to the reverse of the order of development of a nova in its early stages.

The principles involved in Bowen's identification of nebulium have led P. W. Merrill (61) to the identification of certain new lines of iron in stellar spectra. He finds forbidden lines of iron in N. Pictoris 1925, N. Aquarii 1925; η Carinæ (Bep), and HD 42474 (Mep). The qualitative rules of intensity in a multiplet are found to hold, even in the forbidden groups.

Some new identifications of lines due to ionised iron in celestial spectra have been made by F. E. Baxandall, J. A. Carroll, and F. J. M. Stratton (62), using Russell's classification, which is at the same time extended by the filling in of certain unobserved lines from stars and from laboratory spectra taken in Cambridge. The absence of certain lines is ascribed to their intrinsic faintness compared with the other members of the multiplet to which they belong.

Theoretical and Special Investigations.—E. A. Milne (86) has shown that the effect of radiation pressure in an absorption line is unimportant in the interior of a star or in the photosphere, but that it rapidly becomes important near the boundary, and he has investigated the equilibrium of the outer layers.

The theory of Cepheid variation has received attention from J. Woltjer (87), who has applied the new quantum mechanics to the discussion of line absorption inside a star, and so reduces his former estimate of the line absorption coefficient and multiplies Eddington's value by about four. The conditions for pulsation are found and seem to be satisfied by Cepheids. H. N. Russell (88), in discussing the period, luminosity, and spectrum of a Cepheid, shows that if the luminosity follows the mass-luminosity law and variation is due to a dynamical oscillation, then, if there is a relation between period and luminosity, there must be a relation between period and spectrum, and *vice versa*. For normal Cepheids this is true, but cluster variables are peculiar.

Statistical Investigations.—G. Strömberg (96), in a discussion of the absolute magnitudes of giant M stars, gives the method and formulæ used by Adams, Joy, and Humason for determining absolute magnitude of M stars, and discusses the probable errors and the residual systematic errors.

A study of the space distribution of the stars of different spectral classes in the Cygnus region of the Milky Way has been made by A. D. Maxwell (91), using the fainter stars of magnitudes 10 to 14.

Laboratory Spectra.—A discussion in the light of Hund's theory and recent spectroscopic advances of related lines in the spectra of elements of the iron group has been made by H. N. Russell (92), who has correlated homologous terms and lines, and the atomic arrangement involved.

A method of checking and improving measurements of spectrum lines has been developed by C. Runge (93).

During the year many more spectra have been classified, and the systems of classification have developed concurrently with remarkable advances in atomic theory. It is quite impossible to give any account of all this mass of work here, but its astrophysical importance is considerable.

Miscellaneous.—According to P. W. Merrill and M. L. Humason (98) there is a possible discontinuity in brightness in the sequence of giants at a temperature just below that of class M6. Most of the stars of this class and all cooler ones are long-period variables. Still cooler stars are almost non-existent, and this is perhaps due to a sudden decrease in luminosity at this point.

An interesting discussion of interstellar calcium is published by O. Struve (99). He finds that B and earlier stars show detached Ca lines of greatest intensity at a distance of 500 to 600 parsecs, and discusses the intensity of detached K lines as a function of apparent magnitude, distance, and spectral type; there is possibly a correlation with distance. Oscillating CaII lines in O and B stars are discussed by B. J. Bok (100), who explains them as due to a blend of a stationary K line (due to a cloud) and an oscillating K line in the star itself.

E. S. King (101) finds a local absorbing cloud out to a distance of 100 light years from the sun on the basis of a reddening with distance, and discusses the effects of this.

N. T. Bobrovnikoff (111) has investigated the spectra of 22 comets with a recording microphotometer, and finds two distinct types of continuous spectrum, one with a maximum of intensity near $\lambda 4700$ (solar type), and one with a maximum near $\lambda 4000$ (violet type). At distances less than 0·7 of an astronomical unit from the sun the solar type predominates, at greater distances the violet type. Sudden changes in the spectra are found and studied, and reasons are given in favour of the fluorescent origin of cometary spectra.

H. Spencer Jones (102) has made an interesting determination of the constant of aberration and the solar parallax, using the fact that the velocity of the earth contributes to the measured Doppler shift in radial velocity measurements.

J. A. Carroll (103) has investigated the intensity of an absorption line produced by a grating spectrograph, and developed numerical values for the amount of filling in of a line by secondary diffraction maxima.

A. A. Michelson (108) has published the result of his latest determinations of the velocity of light, and gives a value of 299·796 km./sec. Several surveys of the problem have been published, and one valuable one gives corrections of the persistently repeated misprints in the records of older determinations.

In conclusion, the publication of an exceedingly useful and excellently planned textbook must be welcomed in Russell, Dugan, and Stewart's *Revision of Young's Astronomy*, in two volumes, at a very moderate price. J. A. C.

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(80) F. C. Leonard, "Spectrum of Companion of A Cygni," *P.A.S.P.*, **39**, 361.
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(91) A. D. Maxwell, "Space Distribution of Stars of Different Spectral Classes in Cygnus Region of Milky Way," *L.O.B.*, 390.

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(93) C. Runge, "Method for Checking Measurements of Spectrum Lines," *Ap. J.*, **64**, 315.
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(95) R. F. Sanford, "Radial Velocity and Spectrum of RU Camelop," *P.A.S.P.*, **39**, 235.
(96) R. F. Sanford, "Radial Velocity and Spectrum of Cepheid T Monocerotis," *P.A.S.P.*, **39**, 236; and *Ap. J.*, **66**, 170.
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(99) O. Struve, "Interstellar Calcium," *Ap. J.*, **65**, 163.
(100) B. J. Bok, "On the Oscillating Ca+ Lines in O and B Stars," *B.A.N.*, 122.
(101) E. S. King, "Local Cloud of Absorbing Matter," *H.C.O. Circ.*, 299.
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(103) J. A. Carroll, "Intensity of Absorption Line produced by a Grating Spectroscope," *M.N.*, **88**, 154.
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Double Stars.

Measures and New Pairs.—During the year 1927 the results of several extensive series of measures were published.

Professor Van Biesbroeck has given in vol. v., part 1, of the publications of the Yerkes Observatory 6243 measures of 2097 double stars mostly observed with the 40-inch refractor. The list includes all the double stars discovered by Hussey at the Lick Observatory about twenty years earlier. For 290 of these stars sufficient motion has been observed for the hypothetical parallaxes to be calculated. Improved values of the parallax have been obtained by using the mass luminosity relation. The Hussey stars have been classified as follows :—

		No.	Per Cent.
1. Binaries	*a.* Clearly orbital motion . .	23	2
	b. Common proper motion . .	216	16
	c. Plausible hypothetical par. . .	230	17
2. Fixed or doubtful change		820	61
3. Change of unknown character		39	3
4. Optical pairs		14	1
		1342	100

The section on miscellaneous stars contains new orbits for 10 stars for which earlier orbits were in considerable error.

Dr. Voûte in the *Annals of Lembang Observatory*, vol. i., has published two series of double-star observations. The first series was made with the 6·9-inch refractor at the Cape Observatory in the years 1913–17. The results are now published in detail, but the mean results were published in *M.N.*, **75**, 432, and *M.N.*, **78**, 683. There are 631 measures of 164 pairs. The results of the measures of photographs of double stars taken with the Cape Astrographic telescope are also given.

Dr. Voûte's second list contains 2080 measures of 477 double stars made with the 7·4-inch refractor of Lembang Observatory. The list includes important double stars between the equator and Dec. − 65°.

The Greenwich volume for 1925 contains the measures of 424 doubles observed at least three times since 1919. This list follows that published in the Greenwich volume for 1920.

The search for new double stars has been continued with great activity at Johannesburg with the 26½-inch refractor. In *B.A.N.*, 126, Dr. van den Bos gives details of the new pairs B 635 to 794, and in *B.A.N.*, 139, of the new pairs B 795–926. In *B.A.N.*, 126, he discusses the different methods of double-star observing, visual, photographic, and interferometer.

In *L.O.B.*, 383, Dr. Aitken gives positions and measures of 85 new double stars A 3001 to A 3085 mostly of south declination in the zones left uncompleted by Hussey in the Lick Survey. The same bulletin gives the measures of 113 miscellaneous pairs made in the years 1923–26.

Other measures of double stars published in various periodicals are indicated by the following table :—

Author.	Reference.	No. of Stars.	Notes.
Armellini, G.	*A.N.*, **230**, 253	24	Wide.
Baize, P.	*Journ. des Obs.*, **10**, 149, 164	469	Misc.
Berman, L.	*A.J.*, **38**, 37	129	Misc.
Brown, F. L.	*A.J.*, **37**, 120	190	Σ, A, Es, etc.
Ellison, M. A.	*M.N.*, **87**, 465	23	Σ and Sch.
		6	New.
Espin, T. E. and Milburn, W.	*M.N.*, **87**, 215	95	Mostly E and M.
		64	New E.
		70	New M.
Fatou, P.	*Journ. des Obs.*, **10**, 96	114	Misc.
Krumpholz, H.	*A.N.*, **230**, 247	51	Misc.
Leavenworth	*A.J.*, **37**, 141	89	Σ, etc.
Paloque, E.	*Journ. des Obs.*, **10**, 142	95	Misc.
Savitsky, P.	*A.N.*, **230**, 251	18	Very wide.
Schembor, F.	*A.N.*, **230**, 185	88	Many Σ.
,,	*A.N.*, **230**, 329	191	Misc.
Shajn, G.	*A.N.*, **230**, 369	76	Photographic.

Orbits.—In *A.J.*, **37**, 97, K. Laves describes a method for the determination of orbits seen end on from the earth. Besides the 10 new orbits by Professor Biesbroeck alluded to above, new orbits have been computed for other stars as shown in the following list which gives the period in years, the semi-major axis, and the eccentricity.

Star.	Authority.	Reference.	P.	*a.*	*e.*
				"	
A 1928	Aitken, R. G.	*P.A.S.P.*	19	0·17	·50
β^2 Tucani	Van den Bos	*B.A.N.*, 118	41·3	0·477	·668
β 744	,,	,,	64·86	0·521	·565
Σ 1785	Rabe, W.	*A.N.*, **231**, 121	155·71	2·475	·449
Σ 2055	,,	,,	135·29	0·942	·590
Σ 2107	,,	,,	261·82	1·012	·560
Σ 73	Berman, L.	*A.J.*, **37**, 115	118·1	1·00	·73

Miscellaneous.—In *M.N.*, **88**, 51, Dr. H. de Groot gives the results of a study of pairs of stars with separation under 30″ in the Greenwich Astrographic Catalogue ; it is found that up to 20″ separation at least there are many true binaries even amongst faint stars.

E. A. Kreiken in *M.N.*, **88**, 101, discusses the relation of the orbital plane of binary stars to the galaxy.

Southern Double-Star Catalogue.—The loose-leaf catalogue of double stars south of Dec. − 19° to which reference was made in last year's report has been completed by Dr. Innes. This will prove of great use to the increased number of double-star observers in the southern hemisphere. Compared with Dr. Innes' catalogue of 1899, this volume shows a very great advance indeed, although Dr. Innes reminds us that only half of the proposed survey at Johannesburg has been completed. The observational work is being carried on there with great energy. J. J.

Variable Stars.

As in former notes, routine observations and data for individual variable stars which show no marked peculiarities have been considered unsuitable for particular reference in this summary ; they will be found scattered profusely throughout the usual publications. It should be mentioned, however, that the compilation of the annual catalogue of variable stars, formerly undertaken by the Astronomische Gesellschaft, has now been taken over by the observatory of Berlin-Babelsberg. The first publications under the new auspices are reviewed in *Observatory*, **50**, 319.

The exceptional amount of attention recently devoted to variable stars, which was commented on last year, has been well maintained, though little definite progress in the interpretation of the phenomena can be said to have been made. In the following abstracts the customary classification has been adopted as far as possible. A study of variables in general, however, contributed by C. D. Perrine to *A.N.*,

5505, cannot conveniently be classified, and is most appropriately dealt with at the beginning.

Perrine enters upon a discussion of the statistical and individual relations between the more prominent characteristics of variables in globular clusters and in the galaxy. He finds that the range of variation depends upon both period and brightness of the star. The relations, however, are somewhat obscured by the existence of preferences for certain periods, and the Cepheids and Algol variables show complementary behaviour with respect both to these preferences and to the relation between brightness and range of variation. Further, the periods which occur can be arranged in groups, the members of each of which form a geometrical progression with a ratio of $\frac{1}{2}$. These relations are found not only in variables but also in spectroscopic binaries whose light is constant. The following general conclusions are reached :— "(1) All variables, both of light and velocity, are closely united by these relationships and require a common explanation. (2) Direct as well as much collateral evidence points to variability, both of light and velocity, as being due in general to oscillations of an atmospheric envelope. (3) The periods of variable stars, both of light and velocity, appear to be subject to some law of frequency vibration which is a fundamental property of matter or radiation. The most violent breaks with current ideas involved in these conclusions are, first, that "it seems impossible . . . to maintain a theory of eclipses as causing the light variations of the Algol stars," and, secondly, with regard to spectroscopic binaries, "it is difficult to see how we can maintain duplicity in their case." A hypothesis of stellar variation is suggested, according to which all variation is due primarily to pulsations in an atmosphere or envelope, outside the true photosphere, which "consists chiefly of cosmical matter, with enough gaseous matter to produce the absorption lines." "No homogeneous pulsation of a single thin layer appears adequate, but differential oscillations in an extensive, more or less transparent, envelope appear to be sufficiently flexible." Spasmodically decreasing periods are indicated as the evolutionary order in variables. The paper concludes with a discussion of the possibility that the Sun is a variable star, and a comparison of the substance of the paper with Turner's paper (*M.N.*, **73**, 116, 1913) on the relations between the periods of sunspots and the variable S Persei.

Novæ.—In *A.N.*, 5518, M. Wolf reports the discovery, on July 30, of a nova in Aquila. At the time of discovery it was a star of the 9th magnitude. Wolf describes its spectrum on August 17 in *A.N.*, 5519, and photometric observations are given by W. Brunner (*A.N.*, 5520) and J. Voûte (*B.A.N.*, 137). The spectrum on September 5 is described by O. Struve (*Pop. Ast.*, **35**, 448), who reproduces a spectrogram with a micro-photometric tracing. By that date the nova appeared to have reached the "nebular" stage of its development. M. L. Humason (*P.A.S.P.*, **39**, 369) reports further observations, and gives a plate showing five spectra of the nova, extending from August 18 to October 22, compared with recent spectra of Nova Aquilæ, 1918, and Nova Cygni, 1920. The changes in the spectrum of the new nova appear, in the main, to follow the usual course.

Pub. Lick Obs., vol. xiv., part 2, consists of a detailed report by W. H. Wright on the photographic observations of the spectrum of Nova Geminorum, 1912, which were made at the Lick Observatory, together with those of W. S. Adams and his colleagues at Mount Wilson. The report cannot profitably be summarised, but should be read in conjunction with F. J. M. Stratton's earlier memoir on the same star (*Ann. Solar Phys. Obs., Camb.*, vol. iv., part 1), to which frequent reference is made.

In *P.A.S.P.*, **39**, 365, W. S. Adams, M. L. Humason, and A. H. Joy give an account of investigations of the spectra of faint stars and nebulæ (down to the 15th photographic magnitude) by means of a small spectrograph of large aperture and short focal length attached to the 60-inch or 100-inch reflector at Mount Wilson. Among the objects examined are Nova Cygni, 1920, Nova Aquilæ, 1918, and Nova Ophiuchi, 1898 (RS Ophiuchi). The spectrum of Nova Cygni showed little change between 1923 May 7 and 1927 June 14. $N_{1,2}$ appear as strong, bright bands, H_β is faint, and λ 4363 is absent or extremely faint. The continuous spectrum is of moderate intensity and shows traces of absorption. A small displacement towards the red is indicated by the bright bands. Nova Aquilæ on 1927 May 27 and 1927 September 27 showed a very strong continuous spectrum with little detail. H_β, H_γ, H_δ, and λ 4686 were bright and of medium intensity. The transition to the Wolf-Rayet type of spectrum seems to be complete. Nova Ophiuchi on 1923 July 20 showed a very strong, bright H_β and a fainter emission line at H_γ. Several of the prominent lines of ionised iron appear as faint emission lines. The absorption spectrum is difficult to classify, but appears to be about type G5. The radial velocity determined from the bright lines, mainly of hydrogen, is approximately − 35 km. per sec.

The proper motion of Nova Pictoris, determined from plates with an average epoch interval of 24·2 years, is given by W. J. Luyten (*Harv. Bull.*, 852), after correction for parallactic motion of the comparison stars, as $\mu_\alpha \cos\delta = -0''{\cdot}042$; $\mu_\delta = -0''{\cdot}018$. (Mean error in each co-ordinate = $0''{\cdot}013$.) Adopting Davidovich's spectroscopic parallax of $0''{\cdot}006$, a tangential velocity of about 40 km. per sec. is obtained.

The spectrum of P Cygni, the "permanent nova," appears to have undergone decided changes since 1887. These are briefly described by B. P. Gerasimovič in *Harv. Bull.*, 852.

Nova Aquilæ, 1918, has been the subject of two investigations. C. T. Elvey (*Pop. Ast.*, **35**, 138) has examined the spectrograms of this star taken at the Yerkes Observatory two days before maximum brightness, when the bright lines had not made their appearance. The object of the investigation was to test whether the hydrogen absorption lines (which later became bordered by broad emission lines) were unsymmetrical, as it is stated they should be if the displacements of the lines are due to a Doppler effect of expanding gases. Six photographs were examined, and it was found that in each of five lines the region of maximum intensity was displaced to the violet side of the centre of the line.

This star was observed visually by Barnard in 1918 October, and found to possess a nebulous envelope, of which micrometrical measure-

ments were made. E. Hubble and J. C. Duncan (*Ap. J.*, **66**, 59) made photographic measurements of the diameter of the envelope between 1926 May 17 and 1927 April 25, which show that it is expanding at the rate of 1″·0 per year—a rate consistent with Barnard's observations. Early spectrograms gave a linear rate of expansion of 1700 km. per sec., the corresponding parallax being 0″·0028. Recent slitless spectrograms, one of which is reproduced, show a strong image of the disc at λ 4686 (He^+), slightly weaker images at H_β, H_γ, H_δ, and traces at N_1 and λ 4363 (now assigned to O^{++}).

On the theoretical side, the only contribution of note is a paper by C. H. Payne (*Harv. Bull.*, 843), who discusses Milne's radiation-pressure theory of the Doppler displacements in the spectra of novæ. According to the theory the displacements of absorption lines for a nova should vary with the residual intensities of the lines, so that different lines should be displaced to different degrees. This is not in accordance with observation. It is regarded as probable that the origin of the large radial velocities measured for novæ is to be sought in the same cause that produces the brightening of the novæ—both being the effects of an expansion.

β Lyræ Type and Eclipsing Variables.—The recent discovery by Miss M. Blagg (see *M.N.*, **85**, 484) that the period of the known subsidiary variation in the light of β Lyræ has a fluctuation of 1·48 days on either side of the mean value in a period of 3311·28 days, is made the subject of a mathematical investigation by S. Tscherny in *A.N.*, 5504. He finds that the fluctuation can be satisfactorily accounted for by Newton's law of gravitation.

The relations between the spectra, masses, luminosities, and densities of eclipsing variables are examined by D. B. M'Laughlin (*Astron. Journ.*, 889) in the light of data for 48 stars which have been studied spectrographically. A Russell diagram is drawn, which clearly outlines the dwarf sequence. The mass-luminosity diagram indicates a curve of the familiar type, but there are unexpectedly large deviations of individual points from the curve. It is believed that the greater part of this scattering is real, and that we are not justified in saying that the mass and effective temperature of a star determine a unique value of the luminosity. The deviations are most pronounced for the stars of relatively small mass.

A similar discussion, based on data for all known eclipsing binaries, whether observed spectrographically or not, is undertaken by M'Laughlin in *Astron. Journ.*, 892. The stars are divided into two groups, viz. those with known photographic orbits (116 in all) and others. Useful data are tabulated, and a number of stars of abnormal density (high and low) for their spectral classes are indicated and recommended for special study.

The O-type eclipsing variable, HD 1337, referred to in last year's Council note, has now been fully discussed by J. A. Pearce (*Pub. Dom. Ast. Obs., Vict., B.C.*, **3**, 13). The system consists of two giant O-type stars, of linear sizes 23·8 and 15·5, of masses 36·3 and 33·8, and of densities 0·003 and 0·009, compared with the Sun. The stars revolve practically in contact in a slightly elliptical orbit in a period of about

$3\frac{1}{2}$ days. Their exceedingly high temperatures, 28,000 deg. K., and consequent high surface brightnesses, place the stars among the most luminous so far investigated, the components having visual absolute magnitudes, − 5·94 and − 4·83, and bolometric absolute magnitudes, − 8·81 and − 7·30. The deduced parallax is 0″·00032, and space velocity, 146 km. per sec., for the centre of gravity of the system. According to Jeans's theory of binary stars, fission would only recently have taken place, if it is even yet complete.

Stars of the W Ursæ Majoris type (eclipsing variables of very short period) have received some attention during the year. Their spectrum lines are usually diffuse—an effect which may arise from rapid rotation. J. Schilt (*P.A.S.P.*, **39**, 160) investigates this possibility and finds it consistent with facts. He concludes that the stars are probably dumb-bell-shaped bodies in process of fission.

SW Lacertæ, a star of this type with one of the shortest periods known, has been investigated by L. Campbell (*Harv. Bull.*, 845). He finds a change of period of the system of the order of 0·20 secs. for each revolution, confirming a previous discovery by Miss Leavitt but reducing the magnitude of the change announced by her.

In *Harv. Bull.*, 847, M. B. Shapley gives particulars of TT Hydræ, an eclipsing variable in which the stars differ nearly 100 : 1 in surface brightness and show an equal disparity in mean density. The system consists of a small bright star totally eclipsed by a larger, very dark companion.

The rapid spectrograph of small dispersion which, as stated above, has been used by Adams, Humason, and Joy for investigating the spectra of novæ, has been applied also to the measurement of the radial velocity of TU Persei (*P.A.S.P.*, **39**, 365). The remarkably large value of − 350 km. per sec. was found, in comparison with which the variations in velocity are probably small. The spectral type is estimated as A5s.

Cepheids.—Cepheids, as usual, have attracted the greatest amount of attention of a special kind during the year. Twenty-nine faint stars of this type have been subjected to photometric examination by the extra-focal method at the Allegheny Observatory. The 30-inch Thaw refractor was used. The results are reported in an extensive memoir by F. C. Jordan (*Pub. Alleg. Obs.*, vol. vii., No. 1).

The discovery of a new Cepheid of antalgol type in Taurus is reported by A. S. Williams (*M.N.*, **87**, 172). The period is $8^{h}\ 32^{m}$, and there are both long- and short-period irregularities in the main period of variation. The light-curve also shows peculiarities. Data for other antalgols of short period point to the conclusion that these variables are in a state of at least partial instability.

Blazko's photometric observations of W Canum Venaticorum are analysed by N. Bougoslavski in *A.N.*, 5484. There is evidence of a principal oscillation with a period of about 0·55 days and a secondary oscillation with a period of about 0·16 days. The incommensurability of the periods indicates two independent causes of variation, and the presence of a second star is suggested.

R. F. Sanford reports the results of a detailed study of T Monocerotis (*Ap. J.*, **66**, 170), among which it is stated that the maximum velocity

of approach of the origin of the H_γ line is maintained for a much longer time than that of the atoms responsible for the other lines.

In *Journ. Roy. Ast. Soc., Canada*, **21**, 268, F. Henroteau discusses variations of different kinds in the radial velocity curves of the stars ν Eridani and σ Scorpii—two variables of the β Canis Majoris type—indicating a double periodicity. The writer has previously suggested that stars of this type are of the same nature as galactic Cepheids, and he now raises the question whether a double periodicity is characteristic of galactic Cepheids also. Evidence pointing to an affirmative answer is advanced.

W. Zessewitsch (*A.N.*, 5485) calls attention to indications that VZ Herculis has a constant light-curve but a variable period ; further observations are regarded as desirable. In *A.N.*, 5534 the same writer undertakes a mathematical investigation of the periodical changes of period observed in certain Cepheids—in particular, stars such as RW Draconis and XZ Cygni, in which Blazko has shown that the changes of period are accompanied by changes of light-curve. He finds that this phenomenon can be accounted for by the supposition that the observed light-curve represents the superposition of two independent periodic changes. This suggests an explanation similar to that of Jeans, namely, that there is a pulsation of a pear-shaped body on which is superposed a variation of light resulting from the rotation of the body. More complete data would enable a definite test of the theory to be made. It is considered premature to attempt an explanation of secular changes of period which have been observed.

The investigation of the properties of Cepheids by means of a statistical study of spectrum line intensities, previously described by A. Pannekoek and J. J. M. Reesinck and summarised in *M.N.*, **86**, 255 (1926), is now applied in greater detail than before to δ Cephei by Reesinck (*B.A.N.*, 125). He finds that, for the layers which determine the spectrum of this star, (1) with increasing brightness the temperature is higher than with equal decreasing brightness; (2) with decreasing temperature the ionisation is stronger than with equal but increasing temperature.

In *M.N.*, **87**, 414, Reesinck repeats, in English, the substance of a portion of his Dutch paper, summarised in the last Council note (*M.N.*, **87**, 328), in which he maintains that the pulsation theory of Cepheids, as given by Eddington, is discordant with facts. In *M.N.*, **87**, 539, A. S. Eddington discusses Reesinck's criticism, which he does not accept without considerable emendation ; in particular, he dissents from Reesinck's alleged disproof of his assumption that, in the outer layers of a pulsating star, "the temperature oscillations are determined by the heat received and radiated rather than by compression and rarefaction." Eddington's discussion is aided by a further investigation of the conditions in the outer layers, which he describes in the same paper. In his former work on this problem, the precise part played by the outer layers in retarding the time of greatest radiation with respect to that of greatest compression of the star was left unexamined ; it was shown that there should be such a retardation, but the observed value of a quarter-period was not deduced. In the new investigation

the conditions in the outer layers are treated rigorously, with the result that, so far as the factors at present recognised in the problem are concerned, the quarter-period retardation is not accounted for. It is pointed out that this raises a difficulty, not only for the pulsation theory, but for all theories of Cepheids that are at present likely to find favour.

C. D. Perrine (*M.N.*, **87**, 426) raises anew the much-discussed question of the parallaxes of the galactic Cepheids. He maintains that, owing to a strongly marked asymmetry in the parallactic motions of these stars, distances determined from such motions are untrustworthy. He deduces tentative parallaxes from considerations based on the known variables in the Magellanic Clouds and globular clusters, from which it follows that the absolute magnitudes of the Cepheids are of the order of that of our Sun. He further concludes that the peculiar variations in brightness of the Cepheids and Algol variables are not due to great mass or size, and that their densities are of the same order as that of the Sun. In *Observatory*, **50**, 220, however, P. Doig compares the parallaxes of 16 Cepheids, derived from Shapley's period-luminosity curve, with the trigonometrical parallaxes, and shows that the agreement is good. If Perrine's conclusions were correct, the latter figures should be 30 times as large as the former.

In the last Council note (*M.N.*, **87**, 330) reference was made to a criticism by H. Vogt of P. ten Bruggencate's generalisation of Jeans's theory of Cepheids. ten Bruggencate (*B.A.N.*, 123) replies that this criticism is based on a hypothesis of von Zeipel, which he does not accept and which has been previously objected to by Jeans. ten Bruggencate considers that von Zeipel's theorem would require that no star can form a double star. H. Vogt, however, maintains, in *A.N.*, 5512, that ten Bruggencate has not disposed of his criticism.

In *B.A.N.*, 115, J. Woltjer reconsiders the contribution of line absorption in the interior of a star to the total stellar opacity, in the light of a recent determination by Pauli, on the principles of the new quantum mechanics, of the intensity of emission of the various lines in the Lyman series of hydrogen. He concludes that the maximum value of this contribution which was recently given by Eddington must be multiplied by a factor of about 4. The share of line absorption is much greater in large than in small masses, and probably requires a lowering of the mass-luminosity curve for large masses. Cepheids are believed to be stars of large mass and, assuming that they are pulsating stars, line absorption may play an important part in the rate of dissipation of energy in them. This question is discussed, and it is concluded that if, in addition to large mass, a star has a mean ionisation potential in the interior that is large compared with the mean kinetic energy of the particles (as appears to be the state of affairs in Cepheids), the law of change of opacity coefficient with temperature and density is probably able, by virtue of the part played by line absorption, to allow the star a radial pulsation without dissipation of energy. With further knowledge of the absorption processes, the period-luminosity relation might be deduced.

In *Harv. Circ.*, 313 and 314, the question of the period-luminosity

relation for galactic Cepheids is discussed by H. Shapley, with the collaboration, in the former circular, of M. L. Walton. For 70 such stars the "median" spectral type is shown to bear a definite relation to the logarithm of the period, which, it is suggested, may be of use in estimating the periods of Cepheids for which the spectral types are known. Assuming Stefan's law and the relation $P^2\rho$ = constant (P = period; ρ = mean density), it is then shown how to determine relative values of the absolute magnitudes of the stars of known period and spectral type, which may be converted into absolute measure from a determination of the mean parallaxes of the nearer stars. Treating the galactic Cepheids in this way, it is found that they follow a period-luminosity relation in close agreement with the curves (visual and photographic) obtained from the Cepheids in clusters and star clouds. The relation is independent of any particular theory of Cepheid variation, but better accordance between the curves from galactic and cluster variables is obtained by assuming formulæ proposed by Eddington on the basis of the pulsation theory.

In *Harv. Circ.*, 315, H. Shapley discusses a difficulty in the theory of Cepheids which is presented by cluster variables—Cepheids of very short period whose median absolute magnitudes appear to be independent of the periods. In all theories of Cepheids which have attained even partial success, the relation, $P^2\rho$ = constant, is assumed. If this is to hold for cluster variables, however, it appears that either the masses or the surface areas must differ considerably throughout the range of periods found among these stars, although the median absolute magnitudes are remarkably uniform. Reasons are given for regarding such differences as inadmissible, so that the relation between period and mean density must apparently be rejected. The only alternative appears to be that the pulsation period should be associated, not with the mean density of the whole star, but with the density in the interior, and that the various periods found among such stars indicate merely stages in the development of a central nucleus which leaves the total mass, the *mean* density, and the size and brightness of the surface unaffected.

A summary, by J. Jackson, of the three *Harvard* papers just referred to appears in *Observatory*, **50**, 310. Problems similar to those therein dealt with are independently discussed by H. N. Russell in *Ap. J.*, **66**, 122. He shows that if the median total luminosity of a periodic variable star follows the mass-luminosity law, and the variation arises from a dynamical oscillation of some definite sort, the existence of a period-luminosity relation demands also a period-spectral type relation, and *vice versa*. This agrees excellently with observation in the case of the Cepheids. If long-period variation also is due to a dynamical oscillation, the relation between period and density must be roughly the same as for Cepheids. For the cluster-type variables, on the other hand, the period corresponding to a given density must be shorter than for the typical Cepheids, and the dynamical processes taking place in the stars must be essentially different. The exact relations in the cluster variables between mass, luminosity, period, and spectral type are very puzzling. Periodic variables, which are

decidedly fainter than the period-luminosity curve indicates and owe their variability to dynamical oscillations, should be much redder than Cepheids of the same periods. No such stars are known in the galaxy.

An attempt to determine more precisely the character of the relationship between spectral type and period for Cepheids is described by W. S. Adams and A. H. Joy in *Mount Wilson Communication*, No. 100 (*Proc. Nat. Acad. Sci.*, **13**, 391). The logarithms of the periods of 64 typical Cepheids and 27 cluster-type variables are plotted against the median spectral types. On the same diagram, similar data for 44 long-period variable stars are plotted, the spectral types for these stars, however, being those observed near maximum light, the spectra at other times being insufficiently known. It is found that the points for most of the stars of the various classes lie on a smooth curve not very different from a straight line, although there are some conspicuous deviations from the curve, especially among the cluster-type variables and the longer period Cepheids. The result suggests a connection between Cepheid and long-period variation.

In *Harv. Bull.*, 845, M. L. Walton records the distances of 50 Cepheids, determined by means of the period-luminosity relation.

Long-Period Variables.—The absolute magnitudes of all M-type variable stars for which data were accessible (18 stars in all) have been collected by N. Barabascheff (*A.N.*, 5514). He finds that, with two exceptions which are probably eclipsing binaries, the stars are very luminous and have small parallaxes.

A suggestion that Mira-type variables are responsible for the recently discovered highly penetrating cosmic radiation is advanced by A. Corlin in *A.N.*, 5529. Observations by Kolhörster and von Salis on the Jungfrau in 1926 August and September indicate variations, with a period of one sidereal day, in the intensity of this radiation. Corlin assumes that the rays proceed from bodies at an extreme stage of stellar development or from nebulæ. Accordingly, he computes the total radiation from those members of each class of such bodies which were above the horizon of the Jungfrau at various times of day during the period concerned. The bodies investigated are stars of spectral types O, B, M, N, Me, long-period variables, bright and dark diffuse nebulæ, planetary nebulæ, nebulous stars, and spiral nebulæ. He finds that only in the case of the Mira-type variables (classes Me and Se) does the curve of daily variation of total radiation agree with the curve of Kolhörster and von Salis: the agreement is improved if the stars of this type near minimum are excluded. Further observations of the fluctuation in intensity of the penetrating radiation are necessary for more exact knowledge of the correlation. The behaviour of the radiation in its passage through our atmosphere is discussed, but here also more data are required—in particular, a knowledge of the dependence of the radiation on the altitude of its source. It is concluded that, if the suggested correlation is real, there must be a relation between the intensity of penetrating radiation and the appearance of bright lines in the spectra of Mira-type variables.

In *Harv. Bull.*, 847, B. P. Gerasimovič, prompted by earlier

announcements of Corlin's results (*Beob. Zirk., A.N.*, **41**, 1926; *Naturwiss.*, **15**, 356, 1927), attempts to check the conclusions by the following investigations :—

"(i) The total light of all Mira variables of spectral class Md and S which were not more than one-tenth of their period from maximum and were above the horizon of the Jungfraujoch on August 15, 1926, was computed for every two hours interval of sidereal time (73 stars).

"(ii) Since the bright lines in the spectrum of Mira disappear one half period after maximum, the same calculation was carried out for all Mira variables over the interval from one-tenth of the period before maximum to one half period after maximum (232 stars).

"(iii) The same computation as (i) was carried out (omitting all variables with zenith distance greater than 70°) taking into account atmospheric absorption.

"(iv) The same computation as (ii) was carried out, taking into account the atmospheric absorption as in (iii)."

The curves obtained, covering an interval of 30 hours, do not support Corlin's results. Gerasimovič concludes that "if Mira variables are responsible for the changes in penetrating radiation, the intensity of penetrating radiation from Mira must be four times as large as its black body (bolometric) radiation." Reasons are given for regarding this as unlikely.

In *A.N.*, 5529, Corlin severely criticises Gerasimovič's investigation on the grounds that he has confined himself to stars near maximum light, whereas Corlin excluded only those at minimum; that the date chosen by Gerasimovič is 1926 August 15, whereas the data concerning the penetrating radiation were obtained between 1926 August 24 and 1926 September 7; that his data are admittedly subject to an average error of ±11 days in the times of maximum; that his selection of stars as Mira variables is very questionable; and that his curves comparing the variation of intensity of the penetrating radiation with that of the radiation from the stars, on which no scale of abscissæ is marked, are considerably displaced relatively to one another, and are wrongly drawn and wrongly described.

The characteristics of the spectra of S-type long-period variables are described by P. W. Merrill in *Ap. J.*, **65**, 23. The zirconium bands are slightly weaker near maximum, and the titanium bands much weaker. Bright hydrogen lines are absent at minimum and strongest near maximum; their intensities are related to the presence or absence of titanium bands. Bright enhanced lines of iron are visible at maximum, and persist through a considerable portion of the cycle.

Mira Ceti has been the subject of two investigations. In *Harv. Circ.*, 308, C. H. Payne and F. S. Hogg report an examination of the intensity of hydrogen (emission) and calcium lines and titanium oxide bands in the spectrum of this star. Twenty-seven plates were used, obtained within the 90 days following the maximum of 1926–27. It was found that the titanium oxide bands did not alter appreciably in strength as the star fell from $3^{m}\cdot3$ to $6^{m}\cdot5$, and that they cut off only

about 20 per cent. of the photographic light of the star at maximum. The emission lines of hydrogen contributed about $\frac{1}{10}^{m}$ to the photographic light of the star at maximum, and decreased in strength irregularly as the star waned.

The other investigation concerns the parallax of Mira, for which inconsistent results have formerly been obtained because of the influence on the photographs of the then unknown companion star. S. A. Mitchell, taking precautions to avoid error from this source, now finds an absolute parallax of 0″·015 (*Pop. Ast.*, **35**, 140). The proper motion is found to be given by $\mu_\alpha \cos\delta = +0''{\cdot}013$; $\mu_\delta = -0''{\cdot}217$. The values given in Boss's catalogue are respectively $-0''{\cdot}001$ and $-0''{\cdot}237$.

A gradual decline in brightness of RT Serpentis during the last four years is announced by H. Shapley (*Harv. Bull.*, 851). This indicates that the star is either a variable of uncommonly long period (or an irregular variable), notwithstanding its spectrum, cA8, or that it is again involved in the hypothetical obscuring nebulosity from which it slowly emerged eighteen years ago.

A very interesting case of a star apparently involved in a nebula is reported by W. J. Luyten (*Harv. Bull.*, 844). The star, which is variable with a period of about 500 days, appears in the blackest part of the obscure region of Corona Austrina. A discussion of the probable situation in space of the star leads to the conclusion that it is most likely within the obscuring cloud, and that its light is only partially dimmed by a comparatively thin layer of occulting material. A further note (*Harv. Bull.*, 847) calls attention to the fact that earlier observations by H. Knox-Shaw do not agree with the statement that the star is a long-period variable with a period of about 500 days.

The nature of long-period variation is dealt with in *M.N.*, **87**, 720, where J. H. Jeans develops a theory of stellar evolution based on the view, previously presented, that a star must be unstable unless the condition of its interior departs substantially from that of a perfect gas. When a star is first born from a nebula it has the density of a perfect gas, and rapidly contracts until the deviations from this condition become considerable. The contraction then takes the form of an unstable pulsation with a period of hundreds of days and approximately constant amplitude. This is the condition of a long-period variable, and it is therefore suggested that such stars represent a stage in the transition from an unstable, perfectly gaseous mass, to a stable "star" with a liquid core. The oscillations cannot be maintained in stars with masses less than a value between twice and four times the Sun's mass, so that the theory requires that all long-period variables shall have masses above this limit. A star born with a mass less than this starts as a non-variable star.

Irregular Variables.—In *Harv. Bull.*, 842, H. Shapley makes a request for careful observations of R Aquarii. This star, as is well known, is involved in a small, irregular planetary nebula. It has been the subject of two papers during the year. In *M.N.*, **87**, 576, P. M. Ryves discusses irregularities in the light-curve which are exceptionally large

and of an unusual character for this type of variable. They are specially prominent when the star is faint, and sometimes amount to an actual reversal in the direction of light change. Striking changes in the spectrum are reported by P. W. Merrill (*P.A.S.P.*, **39**, 48). In 1926 December, there was a considerable strengthening of the continuous spectrum of the star, and the general character of the spectrum was different from anything previously seen in it. The bright hydrogen lines had broad, dark companions on their violet sides, as in P Cygni, and numerous bright lines, due chiefly to ionised iron, were present. The nebular lines were relatively inconspicuous. The spectrum bore some resemblance to that of the companion of Mira. The changes in the spectrum from 1920 to 1926 correspond in a general way to the reverse of the order of development of a nova spectrum during its early history.

In *Harv. Bull.*, 848, B. P. Gerasimovič gives particulars of RU Aquarii, a variable with very small range and peculiar light-curve.

H. D.

The Rotation of the Galaxy.

If the galaxy is analogous to a spiral nebula it is presumably rotating in its own plane. In any case its markedly flattened form leads us to suspect rotation. Several attempts have been made to detect such a rotation from the proper motions of stars. It is only possible to determine the component rotation about an axis in the plane of the ecliptic ; rotation of the stars about the pole of the ecliptic is inextricably mixed up with the constant of precession so long as there is no better way of determining that constant than by stellar observation. However, if we assume that the rotation is about the galactic pole, a knowledge of one component will fix the whole amount. A determination by Charlier in 1913 gave a general retrograde rotation of the stars in the galactic plane of $0''{\cdot}35$ per century ; his latest result is $0''{\cdot}24$. It requires much faith in the freedom of meridian proper motions from systematic error to attribute significance even to the sign of this difference of $0''{\cdot}5$ per century in opposite parts of the sky ; but the sign is in accordance with the results of another method about to be described, and the magnitude appears to be about right.

If the rotation is like that of a rigid body, the radial velocities as viewed from any point are unaffected by it. But if it is an orbital revolution about an aggregation of mass at the centre of the galaxy, the speed will decrease outwards as in the solar system, instead of increasing outwards as in a rigid body. For simplicity, suppose that all stars are moving in circular orbits so that each has the circular velocity V corresponding to its distance R from the centre. Let the centre be at distance R from us in galactic longitude l_0, and let us observe a star at distance r (small compared with R) in longitude l. Since it is approximately $r\cos(l - l_0)$ nearer the centre its velocity will be $V - r\cos(l - l_0)dV/dR$. For rigid body rotation its velocity would have been $V(R - r\cos(l - l_0))/R$, and it would then have remained at a fixed distance from us. This difference, $r\cos(l - l_0)(V/R - dV/dR)$, is

an excess velocity of the star, and resolving this in the direction l, the velocity of recession of the star is

$$Cr \cos (l - l_0) \sin (l - l_0),$$

where $C = V/R - dV/dR$. In particular if the controlling mass is concentrated at the centre $V \propto R^{-\frac{1}{2}}$, so that $C = \frac{3}{2}V/R$. The radial velocity is then

$$(\tfrac{3}{4}V/R)r \sin 2(l - l_0).$$

This is the method developed by J. H. Oort (*Bull. Astr. Inst. Netherlands*, Nos. 120, 132) for investigating evidence of rotation of the stellar system. Naturally the stars will not all have the circular velocity; in applying the above formula to their *mean* radial velocity in different galactic longitudes Oort appears to be assuming that the galactic system has reached a state in which it is neither contracting nor expanding. The effect may be described as a variable K-term in the radial velocities. If the K-term is analysed according to galactic longitude, the constant part is "Campbell's K," the first harmonic gives a correction to the adopted solar motion, and the second harmonic is Oort's effect. If the second harmonic is well-established it seems impossible to give it any other interpretation; as Oort remarks, "the term may be explained by systematic motions arising from another cause than rotation, but these systematic motions then must bear a remarkably close resemblance to a rotation."

Since the effect increases proportionately to r, the most distant objects should be chosen for examination. Analysing 5 such groups (B3–B5, Bo–B2, bright c stars, faint c stars, planetary nebulæ), Oort finds $l_0 = 322°$, $322°$, $330°$, $321°$, $333°$ respectively, pointing with unanimity to the well-known centroid of the globular clusters in $325°$ as determined by Shapley. Moreover, the amplitude of the term increases with the estimated mean distance of the objects and is quite large compared with its probable error; *e.g.* $9{\cdot}3 \pm 1{\cdot}5$ km. per sec. for Bo–B2, $25{\cdot}1 \pm 2{\cdot}7$ for faint c stars. This with other more fragmentary evidence determines the amplitude as 1·9 km. per sec. per 100 parsecs. Conversely this value can be used to determine the mean distance of any group of objects for which the amplitude has been observed. The distance of Plaskett's calcium clouds comes out at 300 parsecs, of the planetary nebulæ 520–2100 parsecs according to brightness. (I have altered Oort's original figures in accordance with his corrected value of the constant given in his second paper.) Evidence confirming Oort's results is given by J. S. Plaskett in the *Monthly Notices* for January.

From the value of C we can determine V if R is known, or *vice versa*. Thus, if we take Shapley's smallest estimate of 13,000 parsecs for our distance from the centre of the galactic system, we find V = 330 km. per sec. There is independent confirmation of this. Strömberg has found a velocity of 272 km. per sec. (subject to a large probable error) for the mean velocity of the globular clusters. Since the latter extend over the whole system, their mean velocity represents roughly the relative velocity between the stars in our neighbourhood and the centre

of the system ; the velocity is, moreover, in the right direction transverse to R. The central mass which would be necessary to control this motion is $2{\cdot}7 \cdot 10^{11}$ times that of the Sun. This can scarcely be regarded as excessive considering the enormous extension now attributed to the galactic system.

These figures would be modified if we allowed for the fact that the mass is not entirely concentrated to the centre. Oort himself estimates R as 6000 parsecs, but it is not possible to expect much accuracy at present. What is especially needed is a more accurate determination of V by observation of radial velocities of globular clusters. Whilst the investigation fits in beautifully with much of our knowledge, it leaves certain difficulties outstanding. Star-streaming is presumably an independent phenomenon since the stream-vertex is more than 20° from l_0—a difference too large to attribute to errors in the determinations. Oort's hypothesis scarcely seems to admit of the existence of separate star-clouds in the system. We are accustomed to think of the stars within say 1000 parsecs of the Sun as constituting a separate star-cloud ; but evidently the cloud will be sheared as the rotational motion proceeds. In fact, without hypothetical interpretation, the direct evidence of the radial velocities is that the stars in the mean are falling in along the axis $l_0 - 45°$ and expanding along the axis $l_0 + 45°$, which makes it impossible for a limited cloud to keep its shape. Oort was inspired by a theory proposed by Lindblad which postulated a number of subsystems rotating within the galactic system, but his results seem rather to minimise the role of subsystems. Finally we wonder how such a state of rapid revolution of the stars all in one direction round the centre of the galaxy could ever have arisen. But the cause of rotation of celestial objects always leaves us wondering.

A. S. E.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

(*Institutions exchanging publications with the R.A.S. Library are omitted from the list, in order to economise in printing.*)

American Association of Variable Star Observers.
Baltic Geodetic Commission.
Bern, Schweizerische Geodätische Kommission.
British Association for the Advancement of Science, Seismology Committee.
Cartuja (Granada), Estación Sismológica.
Chabot Observatory.
Chaldæan Society.
Chicago, John Crerar Library.
Colombo Observatory.
Cracow, Académie Polonaise des Sciences et des Lettres.
Firenze, Osservatorio Ximeniano dei PP. Scolopi.
Göttingen, Universitäts Sternwarte.
Helsingfors, Finnisches Geodätisches Institut.
India, Meteorological Department.
Kharkov, Astronomical Observatory.
Kyoto, Society of Astronomical Friends.
Kyoto, University Observatory.
Lembang (Java), Bosscha Sterrenwacht.
Lemberg (Lwów), Observatorium der Technischen Hochschule.
Liège, Institut d'Astronomie et de Géodésie de l'Université.
Lourenço Marques, Observatorio Campos Rodrigues.
Louvain, Université, Laboratoire d'Astronomie et de Géodésie.
Mauritius, Royal Alfred Observatory.
Mizusawa, International Latitude Observatory.
Moscow, Society of Amateur Astronomers.
Nantucket, Maria Mitchell Association.
New York, American Geographical Society.
New Zealand Astronomical Society.
Prague, Czech Astronomical Society.
Rugby, Natural History Society.
South Africa, Astronomical Society.
Tachkent, Université de l'Asie Centrale.
Tiflis, Geophysikalisches Observatorium Georgiens.
Tokyo, Institute of Physical and Chemical Research.
Tokyo, National Research Council of Japan.
Toulouse, Académie des Sciences, Inscriptions et Belles Lettres.
Trieste, Regio Osservatorio Astronomico.

Signor G. Abetti.
Signor A. M. Antoniazzi.
M. H. Arctowski.
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P. Doig, Esq.
Rear-Admiral F. C. Dreyer.
Dr. J. L. E. Dreyer, the Executors of the late.
F. Dümmlers Verlag, Berlin.
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W. O. Matthews, Esq.
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South Africa, The Director of Census.
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Signor F. Zagar.

ADDRESS

Delivered by the President, the Rev. T. E. R. Phillips, on presenting the Gold Medal of the Society to Professor R. A. Sampson, for his Theory of the Four Great Satellites of Jupiter.

It is probable that of all objects beyond the reach of naked-eye vision the *Four Great Satellites of Jupiter* have made the strongest appeal to popular imagination, while scarcely less has been the interest they have aroused among astronomers of all types, from the amateur with a small instrument to the student of gravitational theory. They were the first objects to be discovered with the telescope, and since that historic 1610 January 7 when Galileo with his newly constructed instrument saw them for the first time they have been associated with the story of man's progress in knowledge and intellectual achievement.

Reference to their discovery carries us back to the days when the conflict between the old and the new theories of the universe was particularly acute. It is true that some eighteen centuries earlier the heliocentric theory had been taught by Aristarchus of Samos, but this had long been forgotten, and the inertia of tradition, fortified by the authority of great teachers like Aristotle and Ptolemy and the weight of ecclesiastical opinion, made it very difficult for the simpler explanation of the planetary motions revived by Copernicus to win its way. In our times of rapid progress new conceptions, however revolutionary, when once shown to be well-founded and consistent with related phenomena, are in general readily assimilated, even though their acceptance may involve the more or less painful process of shedding beliefs long cherished and hitherto regarded as unassailable. But in the days of which we are thinking it was not so, and the spectacle of a planet round which there revolve perpetually four attendant orbs presented an analogy to the heliocentric conception which in some quarters was a highly unwelcome piece of evidence. One hero of the old school, we read, refused to put his eye to the telescope lest he should see the satellites and be convinced—a striking illustration of an attitude of mind unfortunately not limited to the seventeenth century!

Sixty-five years after their detection by Galileo these satellites of Jupiter were associated with another and extremely important step in man's scientific progress, viz. the discovery by the Danish astronomer, Römer—the inventor of the transit instrument, meridian circle, and prime vertical instrument—of the progressive motion of light. Noticing that the intervals between the eclipses of the first satellite on entering the planet's shadow varied with the changing distance of Jupiter from the Earth, he put forward the explanation that light takes time to travel from one point to another and derived a value for its velocity. His suggestion, however, was so contrary to received opinions that it was not till it found confirmation in Bradley's discovery of aberration half a century later that it gained general acceptance. And although it has long been recognised that certain inherent difficulties render

Römer's method incapable of the accuracy and precision obtainable by modern experimental methods, it is of much interest to recall this historical association of Jupiter's satellites with the evaluation of one of the fundamental constants of Nature.

But the satellites of Jupiter have proved of great service in another way. In the words of Sir John Herschel, "The first astronomical solution of the great problem of 'the longitude'—practically the most important for the interests of mankind which has ever been brought under the dominion of strict scientific principles—dates immediately from their discovery." It is clear that if, say, the Greenwich times of their phenomena are predictable with the requisite accuracy, the differences between the times so predicted and the local times of any place at which the phenomenon are observed will give the longitude of that place. Unfortunately the method is not a feasible one at sea for an obvious reason, but I was interested to read lately in our library a book by the celebrated and versatile William Whiston—sometime Professor of Mathematics at Cambridge—which was published in 1738 and dedicated to the Honourable the Commissioners appointed by Act of Parliament for the discovery of the longitude at sea, in which he proposed to observe the satellites by means of a specially designed refracting or reflecting telescope. His refracting telescope was to be provided with seven object-glasses ground together on the same tool and placed on the surface of a sphere of the same radius, with one eyepiece of large size common to them all; the idea being that despite the rolling of the ship the satellites might be caught through one or other of the objectives. In describing (and very fairly) the respective advantages and disadvantages of his proposal for getting Greenwich time from the satellites and the use of one of Mr. Harrison's clocks for the same purpose, he remarked that "Jupiter's planets will go as true after a storm as before it" whereas this could not be expected of a clock. In the same volume Whiston anticipated our Medallist by developing a theory of the satellites and publishing tables of their phenomena and configurations from the latter part of 1738 to 1742 for the benefit of navigators.

But to turn to the special subject before us—the work of Professor Sampson—it seems proper to remark here that the study of the satellites and the development of their theory are things which call for research quite apart from any resulting utilitarian advantages. In their relative motions and their mutual disturbances these satellites present problems of very great interest to the mathematical astronomer, for, as Laplace remarked in referring to the century and a half of eclipse observations of Satellite I., prior to his time, they exhibit in a short period "those great changes which time produces with great slowness in the planetary orbits." I feel assured, then, that it was in the pure love of inquiry into these problems that Professor Sampson undertook that arduous task, calling at once for unwearied patience and mathematical skill, which your Council has acknowledged by to-day's award.

As in the case with scientific investigations in general, Professor Sampson built upon foundations laid by his predecessors, and amongst them I must specially mention the names of Laplace, Delambre,

Damoiseau, and Souillart. Referring to Laplace, Professor Sampson opens the account of his theory in vol. lxiii. of the Society's *Memoirs* in these words : " Regarded as a piece of mathematics there is no part of Laplace's *Mécanique Céleste* more brilliant than his theory of the satellites of Jupiter."

We all remember amongst other things how that Laplace discovered a very remarkable relationship between Satellites I., II., and III., viz. that the mean motion of I. plus twice that of III. is equal to three times that of II., so that their mean longitudes (L) satisfy the equation

$$L_I + 2L_{III} - 3L_{II} = \text{constant}.$$

This constant is 180°, and in consequence of the mutual action of these satellites that value cannot be permanently altered, any slight disturbance such as might arise from the attraction of IV. being in the long run exactly compensated. The three satellites can therefore never come into opposition or conjunction with the Sun at the same time.

Full acknowledgment is also made by Professor Sampson of the contributions of Delambre. This astronomer not only supplied material on which Laplace worked and which formed part of the basis of our Medallist's own labours, but himself derived elements and constructed tables of the satellites. Later came the work of Damoiseau which was further developed by Souillart. After the expiration of Damoiseau's tables in 1880 the predictions were continued in our *British Nautical Almanac* by means of tables by J. C. Adams (extended after 1900 by A. M. W. Downing), and in the *American Ephemeris* by D. P. Todd's tables, but of both of these the work of Damoiseau was partly the basis. In his preliminary revision of the elements of the satellites Professor Sampson made much use of the data and formulæ in Souillart's recension of Damoiseau.

We must now consider the observational material utilised by Professor Sampson. This was of two kinds, viz. (*a*) old observations prior to 1893, and (*b*) photometric observations of eclipses made at Harvard between 1878 and 1903.

The old observations naturally fall into two divisions. There is first, the very remarkable collection, numbering about 6000, gathered by Delambre from many sources. Much of this material is rough and suffers from certain inherent defects, but it is nevertheless of value for the determination of quantities which need age in the observations to fix them with exactness. Professor Sampson has accordingly utilised nearly 1000 ancient observations of II. and nearly 500 of IV. in deducing respectively the motions of the node of II. and the apse of IV.—two elements of importance in deriving the masses of the satellites and the ellipticity of Jupiter. The second division of the old material consists of eclipse observations of III. made in the ordinary way between 1837 and 1893. A special feature of the orbit of this satellite is that it possesses a well-marked secondary ellipticity which is related to the axis of IV., and it is by disentangling the two eccentricities and evaluating the second " equation of the centre " that the mass of IV. can best be found. For this purpose a long and continuous, but not necessarily

ancient, series of observations is required; hence the value of these particular observations to our Medallist. They, together with the ancient observations of Delambre's collection, are given in detail and discussed by Professor Sampson in vol. lix. of the Society's *Memoirs*.

The photometric observations of eclipses made at Harvard were used in the determination of the other elements required for the theory. The series had been inaugurated by Professor E. C. Pickering in 1878, because of the uncertainty inseparable from observations in which the times of eclipse are determined by the simple visual disappearance of a satellite as it passes into the planet's shadow or its reappearance on emergence from it. Such times must obviously depend very largely on the aperture of the instrument used, the state of the atmosphere, and the personality of the observer. In the observations with the photometer, on the other hand, the satellite undergoing eclipse is compared at frequent intervals of a few seconds with one that is uneclipsed, and the moment of half obscuration—or the instant when the Sun, rim of Jupiter, and centre of the satellite are in line—deduced from the form of the light-curve given by the observations. It will be clear, too, that the steepness of the curve will be affected by the part of the shadow traversed—the process of disappearance or reappearance being extended if the latitude of the satellite is high—so that these photometric observations provide data for the determination of both longitude and latitude.

Professor Pickering's theoretical curve for comparison with the observations is given in tabular form in *Harvard Annals*, **52**, 18. Professor Sampson in his reductions adopted a somewhat different plan. First he expressed the observations in a convenient form which rendered comparable eclipses at different latitudes and plotted them on squared paper. He then calculated the theoretical light-curves for the individual satellites according to the theory of eclipses as worked out by him and published in *Harvard Annals*, **52**, assuming successively a number of values for their radii near those given by micrometer measurements. These curves were then drawn on tracing-paper and compared with the smoothest and presumably the best of the graphs. In each case that one which showed the most satisfactory fit was selected and thereafter used as a template with which all the observations of that particular satellite were compared.

It has perhaps been a cause of some surprise that Professor Sampson limited himself to the use of eclipse observations, in view of the fact that there was much other material available at the time, including the series of Cape heliometer measures, and photographic plates taken at the Cape, Helsingfors, and Pulkowa. But, no doubt, Professor Sampson had what he regarded as good and sufficient grounds for restricting his material to eclipse observations. We recall the fact that Damoiseau's and all the earlier tables of the satellites had been based solely on such data, and the Harvard photometric work had the very definite advantage of being homogeneous.

Following on the reduction of the observations in the way described, Professor Sampson made a thorough investigation of the existing theory and derived two sets of revised constants by applying the

respective corrections indicated by the Harvard and his own (Durham) readings of the observations.

A number of checks, natural and experimental, followed, and the results were found very satisfactory. For example, the two sets provided eight independent determinations of Jupiter's equatorial semidiameter, and these actually agreed within 0″·1! Moreover, Laplace's theoretical relation for the mean longitudes was satisfied with almost complete exactness. Among the experimental tests were trials of different values for the position of Jupiter's equator and changes in the adopted radii of the satellites, but it was not found that any improvements were thereby introduced which suggested the desirability of modifying the elements. One test, however, gave results which seemed very disappointing. A computation of the times of the observations from the elements revealed unexpectedly large discordances. It may be recalled that Delambre had experienced a similar disappointment. "Les erreurs des nouvelles Tables," he wrote, "sont moindres que celles des premières ; mais ce que nous avons gagné ne vaut peut-être pas le travail qu'il a coûte." Professor Sampson, however, was able to satisfy himself that the larger discrepancies at any rate were such as no allowable change in the elements could remove, and suggested that they probably arose from an external cause provided by Jupiter himself. I will return to this most interesting point later.

We will pause here for a moment to note our Medallist's estimate of the position of the theory of the satellites at this time and the nature of the task by which he was faced. At the end of vol. lii. of *Harvard Annals* he wrote: The theory "was in a state of confusion without example in modern astronomy, partly from neglect, partly from error, partly because the excellent work which Souillart and others have done was complicated by mutually different elements and systems, and had to be co-ordinated by means of corrections before it could be used at all. . . . Upon review of the whole I am of opinion that the confusion of theory and tables was too great to allow a conclusive treatment of these observations at a single step. Before committing myself to my final system, I did what was possible to make preliminary investigations, but anything less than a complete, simultaneous treatment of the whole is of little value except to myself. . . . The best course will be to construct from these [revised values] and other clear data a complete, consistent, gravitational theory, whence the masses may be derived and a set of Tables calculated with which at some future date the available observations may be compared without so much uncertain and experimental labour as the present review entailed."

On this further task Professor Sampson embarked at once, and his work on the perturbative functions in the gravitational theory is given in detail in vol. lxiii. of the *Memoirs*. The Tables based on the Theory were published by the University of Durham in 1910 under the title *Tables of the Four Great Satellites of Jupiter*, and they have since been used for computing the phenomena for the National Ephemerides, but it was not until about ten years later (1920 January) that the full account of the theory itself was communicated to the Society.

Before entering upon the final calculations it was necessary to adopt

definite values for the constants required. These constants are 31 in number, viz. the 24 belonging to the 12 equations of motion of the four satellites, the masses of the satellites, the oblateness of Jupiter, the inclination of his equator, and the position of his nodes. From an examination of the probable errors Professor Sampson had concluded that the values derived from the Durham readings of the photometric observations were somewhat better than those derived from the Harvard readings, but the differences were small considering the diversity in the methods employed. Feeling unwilling either to ignore the Harvard figures or to assign to them an arbitrary weight he finally adopted the simple means of the two sets, except where it was necessary to amend quantities which had been tentatively adopted or to substitute precise values for the slightly differing ones deduced from the observations of the separate satellites. The figures for the motions of the node of II. and the apse of IV. were, as already mentioned, derived from a discussion of the old eclipse observations.

A perusal of vol. lxiii. of the *Memoirs* shows what an immense deal of labour the calculations involved. As regards the actual methods followed I will quote Professor Sampson's own words: "The method of variation of elliptic elements, which is employed by Souillart and also, essentially, by Laplace, seems on the whole ill-suited to the satellites of Jupiter, where in many cases the perturbations exceed the elliptic terms, to which they must be added as corrections. There is besides Hansen's well-known criticism that the method requires us to find six quantities, when all we seek are the three functions of those quantities which represent the co-ordinates. Hansen's own idea of finding directly the absolute perturbations of the co-ordinates is much nearer the mark, though his method presents features unsuitable to this problem. For instance, I have found no use for his device of adding the perturbations to the mean anomaly of an ellipse of fixed form; it is a device which loses its point when the eccentricity is small. Again, his treatment of the motion of the apse is unsuitable, for here we require an explicit and simple treatment, as the motions of the apses, or more correctly of the principal elliptic or pseudo-elliptic arguments, play a very prominent part in the theory of the satellites. But a likeness will be seen in the distinction introduced (and afterwards suppressed) between the time as brought into the disturbing function by the perturbed body and the perturber; and my treatment of the motion of the central plane and axes of reference was suggested by that given in section 1 of his *Auseinandersetzung*." The actual computational work, as I have remarked, was of a very heavy and exacting kind, and as a check upon it all the steps were gone through in duplicate. Some of the secular terms range between a few years and six centuries, the latter being the equivalent of 100,000 revolutions of Satellite I. Since, then, such terms have to be integrated, the necessity of a very high degree of accuracy in the theory will be appreciated.

In the final presentation of his work Professor Sampson has made reference to a few points of special interest which these four satellites exhibit, and amongst them I may mention the following:—

There is a remarkable prevalence of what are termed "induced

equations of the centre," that is to say, equations of the centre which are referred, not to the apse of the perturbed satellite, but to that of the perturber. I have already mentioned this in connection with the eccentricity of III., whose two equations form, as Laplace put it, a variable equation of the centre corresponding to a perijove whose motion is not uniform. A similar perturbative effect exists in the theory of the planets, but Professor Sampson has remarked that it is among Jupiter's satellites that it becomes prominent, the induced equations being sometimes greater than the proper equations.

Another interesting fact arises from the terms which are dependent on the mutual elongations of I. and II., and II. and III. They involve long inequalities of the first order, and in some respects the calculation of them is more troublesome than that of finding the long inequality of the same order of the system of Uranus and Neptune.

And there is another peculiarity which I will describe in Professor Sampson's words : " The periods of the two inequalities thus impressed upon, say, Satellite II. by Satellites I., III. are absolutely identical. These result analytically in actual disappearance as an independent co-ordinate of one of the three longitudes, a libration shared by the three satellites replacing it. It appears from the observations that this libration is itself of small amount if not insensible, but its theoretical presence has the remarkable effect of distributing among the longitudes of the three satellites certain long inequalities which would naturally rise into sensible value in the case of the third alone."

I must now bring my very inadequate account of our Medallist's work on the satellites of Jupiter to a conclusion with a few general remarks. And first I would say that he does not claim for his theory that it is final or complete. After a preliminary comparison of his tables with the observations (*M.N.*, **71**, 76) he wrote : " From the results it is apparent that there still remains a good deal to do in the problem of Jupiter's satellites," and in the last chapter of his *Memoir* we find reference to certain omissions from the Theory, the most important being one relating to Satellite IV., which Mr. Innes referred to in a review of the Tables (*Observatory*, **33**, 478), and which Professor Sampson has described as " an induced equation of the centre due to the action of the Sun regarded as a fifth satellite." But the effect of these omissions and of certain small errors can only be slight. What is of more general interest is the fact (similar to that already mentioned in connection with the residuals in *Harvard Annals*, **52**) of the discordance between calculation and observation, or, to quote Professor Sampson's own words, " the comparatively poor success of the theory in reproducing the observations." As a matter of fact, on recomputing the Harvard eclipses from the Tables, no improvement in the residuals as given in *Harvard Annals*, **52** was found. Some of them were even very slightly greater ; and although such a result might be quite natural in view of the changes introduced in certain terms of the theory and the substitution of compromise values for the slightly differing quantities before applied to the observations of the separate satellites, some feeling of disappointment could hardly be avoided.

This was not, I imagine, the kind of issue looked for when Professor

Sampson first entered on his great task, but he accepted the facts in the true scientific spirit. "It may be difficult," he wrote finely, "not to feel some disappointment that the outcome of an elaborate work is not more striking, even if one is not the author of it. But such a feeling is quite unreasonable. Discrepancies may or may not be explicable by improvements of geometrical and dynamical theory. It is a duty laid upon the mathematical astronomer to show whether they are so or not. It is a peculiarly onerous business in questions of astrodynamics in their present advanced state, and should only be undertaken by those who find a reward in making the actual mathematical developments. But if in the end it establishes that there are features in the observations which an exact geometrical theory can certainly not explain, scientifically speaking, that is no matter for regret. On the contrary, it becomes important if we are satisfied that the margin between observation and theory is greater than can be ascribed to the defects of both."

This brings us back to Professor Sampson's suggestion which I have already mentioned, viz. that Jupiter himself is responsible for the larger discrepancies between calculation and observation. They could be explained if Jupiter is not exactly a spheroid of revolution, but possesses unequal axes; or if from time to time cloud-like protuberances affect the boundary of the planet's shadow and cause discordances in the observations. That such a source of disturbance is possible seems more than likely. Professor Sampson has pointed out that in order to accelerate the time of an eclipse by 30^s such a protuberance must have an altitude of about $\frac{1}{140}$ of the planet's radius, or some 300 miles. This seems by no means an improbable value in view of what we know of Jupiter, and on occasions it might be considerably exceeded. In 1919 members of the Jupiter section of the British Astronomical Association observed in the equatorial region three objects which, contrary to the usual behaviour of white spots on Jupiter, appeared as bright projections (probably in part an exaggerated effect of irradiation) at the planet's edge, but were lost to view or were inconspicuous when well on the disc. They were observed at both limb and terminator during many rotations.

Another disturbing cause may be an atmosphere enveloping Jupiter of varying transparency and refractive power producing effects comparable with the variable *lumière cendrée* observed during eclipses of our own Moon. Professor Sampson believes that in the peculiarities of many of the eclipse light-curves he has evidence of some such atmosphere, and the photographs of the planet taken recently by Dr. Wright at the Lick Observatory in ultra-violet and infra-red rays, showing a marked extension of the disc with the former, seem to point in the same direction.

These conclusions are exceedingly interesting, but, unfortunately from the point of view of the prediction of satellite phenomena, they suggest that it is hopeless to look for much greater precision than that now reached by the use of Professor Sampson's Tables. At any rate he has given clear expression to his views on this point at the conclusion of his *Memoir* in these words: "If a subsequent calculator handles this

Theory or produces a different one, to the best of my judgment no considerable amelioration of the agreement of theory with observation is to be looked for beyond the numbers reached in *Harvard Annals*, **52**, 293, 309, viz. Satellite I. ± 6^s, Satellite II. ± 9^s, Satellite III. ± 11^s, Satellite IV. ± 22^s by any such further revision." It is, I think, commonly known that a new theory by another distinguished astronomer is "on the way." It will be a matter of much interest to see how far Professor Sampson's experience is repeated.

But whatever the future may show in this respect, it is a fine achievement which is acknowledged by the presentation of the Society's Gold Medal this evening. It is the outcome of several years of exacting labour carried through with scrupulous care; it reveals no small measure of skill in the devising of methods to meet the special requirements of the case in hand; and it has supplied to practical astronomy that which had long been a desideratum, viz. a consistent, self-contained system of Theory and Tables of Jupiter's Four Great Satellites.

Fellows will, I am sure, agree that I cannot conclude this address without some reference to other departments of Professor Sampson's work.

In 1892 the Society published an important *Memoir* by him (*Mem.*, **55**) on the rotation and mechanical state of the Sun, and he has retained his interest in solar matters to the present time.

It will also be remembered that during his directorship of the Durham University Observatory he was concerned with the erection of the instrument known as the Durham Almucantar. It was based on the design of that set up by Chandler at Cambridge, U.S.A., in 1884, and attracted a good deal of attention at the time.

In 1900 he edited the unpublished manuscripts of J. C. Adams's lectures on the Lunar Theory, and notes on various other subjects, including the Theory of Jupiter's Satellites. These were published in vol. ii. part 1 of Adams's *Collected Scientific Papers*. They were quickly followed by "A Description of Adams' Manuscripts on the Perturbations of Uranus" (*Mem.*, **54**, 143), which includes a facsimile reproduction of the actual working of the first solution of the problem (1843).

I must also refer to another matter with which our Medallist was closely associated in his Durham days, viz. a project which did not mature, though it may yet do so. Indeed, but for that achievement of his which is specially in our minds this evening, the scientific world would in all probability have long ago experienced its fruition in the shape of a complete edition of Newton's scientific works and correspondence. The fact is that such a production had been arranged for under the auspices of the Cambridge Philosophical Society, and Professor Sampson had been appointed editor-in-chief.

Things actually progressed as far as the construction of a scheme of publication, but the heavy work of computing the theory and tables of Jupiter's satellites—a work which Professor Sampson has told us he might never have finished had he allowed any other task to take priority of it—intervened, and the editing of the Newton manuscripts

was dropped. But the desirability of such an edition was raised again from this chair by the late Dr. Dreyer at the annual meeting in 1924, and this brought from Professor Sampson a full account of the scheme so carefully planned twenty years earlier, together with some comments suggesting that in the interval doubts had arisen in his mind as to the wisdom of a fully qualified astronomer devoting to it so much of his time as would inevitably be required. But be this as it may, we note how much of the preparatory work has already been done under Professor Sampson's guidance, and I think there must be many Fellows who hope that the scheme may yet be carried through to completion.

In 1910 Professor Sampson moved to Edinburgh on being appointed Astronomer Royal for Scotland, and his direction of the Royal Observatory there has been marked by manifold activities. Much attention has been given by him to optical matters, and in papers published in the *Philosophical Transactions of the Royal Society*, and our own *Monthly Notices* he has investigated the geometrical faults in the fields of reflecting telescopes of the Cassegrain and Newtonian types and proposed methods of removing them.

But one of the outstanding features of his directorship of the Observatory has been his close attention to all matters connected with the determination and recording of time—including an investigation of the errors of the Edinburgh Transit Circle, the performance of the Observatory clocks, and the comparison of their readings with wireless time-signals. A critical study of the behaviour of the clocks was published in the *Proceedings of the Royal Society of Edinburgh*, vol. xliv., following two previous papers in the same publication (vol. xxxviii.) under the title, "Studies in Clocks and Time-keeping." There are now four Standard Clocks at the Observatory—Shortt No. 4 having been added to the equipment in 1926. The temperature control appliances have been reconstructed, every care is taken to ensure the highest possible accuracy in the records, and the clocks are compared with one another daily by means of a microchronograph to $0^{s}\cdot001$.

But perhaps the most valuable part of our Medallist's work in recent years has been the contribution he has made to Astrophysics by his special adaptation of the photoelectric cell to the photometry of stellar spectra. In this research—in which he has had the valuable assistance of Mr. E. A. Baker, whose skill in the construction of apparatus is well known—the spectra to be examined are passed in front of the slit of the instrument, and in the resulting *photograms* (as Professor Sampson has called them) the density of the deposit is indicated by the ordinates. The distribution of energy in the spectrum is accordingly shown by the general rise and fall of the curves, while absorptions and bright lines appear as serrations. The method has the great advantage of being entirely impersonal, the spectra being reproduced quite automatically as graphs.

A paper on the effective temperature of 64 stars as determined with this instrument was communicated to the Society three years ago, and the work is being continued with the prospect of increased success in the future.

Professor Sampson, it is an immense pleasure to me, as well as an

honour which I much appreciate, to present to you this Medal. In so doing I wish to couple with it the Society's most hearty congratulations on the approaching extensive re-equipment of the Edinburgh Observatory. We are delighted to know that you are to have—amongst other things—a 36-inch reflecting telescope furnished with a fine spectrograph; and we hope that not only may these and the other instruments promised be completed and erected as speedily as possible, but that you may find much joy in their use.

ADDRESSES

Delivered by the President on presenting the Jackson-Gwilt Medal and Gift to Dr. W. H. Steavenson for his work on Faint Variable Stars and Novæ, and on the Herschel Instruments, and to Mr. William Reid, for his discovery of Six New Comets.

It is now my very pleasant duty to present to Dr. Steavenson the Jackson-Gwilt Medal and Gift awarded to him by the Council for his work on variable stars in their fainter stages, novæ, and the Herschel instruments.

For some years past Dr. Steavenson has been one of our leading amateur astronomers, and no one can examine his numerous papers and notes without recognising the alertness, freshness, and marked ability which distinguish his work—qualities which have gained for him the position he now holds as President of the British Astronomical Association, and which your Council has acknowledged by this award.

Dr. Steavenson was led, while still at school, to the study of astronomy through his interest in optics, and I think we have in this fact the key to the particular nature of his astronomical activities.

The capabilities of the eye, the defining and space-penetrating power of telescopes, and the celestial objects observable with them are in natural sequence; and to each of these departments of study Dr. Steavenson has devoted much attention.

With reference to the eye and its performance in astronomical observations, it will be remembered that several years ago (1916), he found that, whereas the average diameter of the pupil is commonly assumed to be $\frac{1}{5}$-inch, this is only a *daylight* value, and that in the dark, as shown by flashlight photographs, it is actually $\frac{1}{3}$-inch—an interesting and important point. Telescopes, as we all know, have such an attraction for him that whenever in the course of his travels he comes across one, if there should be a star available for observation, he immediately examines and records the nature of its out-of-focus discs, and in this way he has gained an intimate knowledge of the virtues and defects of many instruments throughout the country. And it was under the very special fascination which telescopes with historical associations have for him that he carried out the careful and detailed examination of the Herschel instruments for which the opportunity was so kindly provided by the present members of the Herschel family.

A full account of this research is published in the *Transactions of the Optical Society* (vol. xxvi. No. 4), and therein we find (*a*) a paper under the title "A Peep into Herschel's Workshop," and (*b*) a "Catalogue of Instruments made and (or) used by Sir William Herschel, as preserved at Slough and examined there in 1924 May and June." In the first of these is a general survey of the work done, together with notes on particular instruments and their optical properties and characteristics. It is interesting to read that Dr. Steavenson has found most of Herschel's mirrors to have very even and regular curves, and though several of them show distinct over-correction, he does not think that, in view of the large ratio of their focal length to aperture, their performance should be very seriously affected by this fault. One telescope of 7-foot focal length, of which the figure is excellent, was found to give exquisite definition on stars, moon, and planets.

Most of the eyepieces used by Herschel were single lenses; and Dr. Steavenson has settled the question as to the very high powers which Sir William Herschel claimed to have used with a 7-foot telescope, but in regard to which doubt has often been expressed. No less than nine eyepieces were discovered, which on a 7-foot telescope would give magnifications in the thousands (of diameters), and the smallest has a focal length of only 0·0111 inch, corresponding to a power of 7676!

The *Catalogue* contains lists of the mirrors, flats, eyepieces, and other apparatus found at Slough, together with details of figure, aperture, focal length, etc., as deduced from the very careful measurements that were made.

This monograph by Dr. Steavenson, which is illustrated by a number of excellent photographs, is a work of very great historical interest to all those—and every British astronomer will be among them—who have felt the wonderful inspiration of Herschel's life and work. I will add that in February of last year Dr. Steavenson discovered, hidden away under the stairs of the cottage at Observatory House, Slough, the first of the two 4-foot specula belonging to the great 40-foot telescope.

As a practical observer Dr. Steavenson has worked in many fields, but the Council in making this award has specially mentioned his observations of variable stars and novæ. Following naturally upon his interest in optical instruments, photometry has from the first made a particularly strong appeal to him and is the subject of a large proportion of his papers. He has the advantage of a keen eye with a marked capacity, which all do not possess, for making very effective use of "averted vision." He has also been fortunate in the opportunity afforded him, by the kindness of the Astronomer Royal, of supplementing his own instrumental equipment at West Norwood by the use of the 28-inch refractor at the Royal Observatory at week-ends. With this instrument he has been enabled to keep under observation a large number of variable stars which in their fainter stages and near minima are beyond the reach of observers with ordinary telescopes. The importance of following such stars right through their minima so as to obtain complete light curves will be recognised by all students of variable stars.

But, as I think, of still greater value is the work Dr. Steavenson has

done on novæ, and in regard to this it may be truly said that Barnard's mantle rests upon him. He detected independently *Nova Aquilæ* (1918), and *Nova Cygni* (1920)—the latter two days after its discovery by Denning, when he was in a village away from such things as newspapers, and the star was situated in a twilight sky and as faint as 2·8 magnitude—but I am thinking especially of his persistent observations of a number of novæ in their final or fainter stages at which they have been so much neglected by observers in general.

I will here try to summarise the results of Dr. Steavenson's work on these novæ in a few sentences. Some of them on returning to what were presumably their magnitudes before their outburst have become sensibly constant in light. This applies to *T Coronæ* (1866), *Nova Lacertæ* (1910), and *Nova Geminorum* (1912). And if Tycho's star of 1572 is still visible (which is not certain), it seems that this, too, must be constant, since no star in its field has shown any change. But other novæ are unquestionably still variable, and these include *Nova Ophiuchi* (1848), *Nova Cygni* (1876), *Nova Persei* (1901), and *Nova Aquilæ* (1918), while Denning's star, *Nova Cygni* (1920), is still fading though seemingly without irregularities. Of these stars *Nova Persei* shows much the largest range, viz. about two magnitudes. Its variations had been under observation by Barnard with the 40-inch refractor at Yerkes, and it is a matter of interest to note that the subsequent publication of his figures confirmed the oscillations and low magnitudes observed by Dr. Steavenson with his 6-inch telescope at West Norwood. The fluctuations of this star are irregular, but with certain indications of different periods acting simultaneously.

As is well known, novæ in their later stages frequently become nebulous. The particularly interesting case of the nebula surrounding *Nova Persei* as the great outburst subsided will be at once recalled, but there is also what seems to be a permanent wisp of nebulous matter attached to this star which was first seen by Dr. Steavenson with his 15-inch reflector in 1916. The other stars I have mentioned, with the exception of *T Coronæ* and the two in *Cygnus*, are also more or less nebulous, while the image of *Nova Ophiuchi*, as seen in a refractor, comes to focus slightly beyond ordinary stars.

All these data which Dr. Steavenson has been collecting about novæ are of great interest and of importance for any future enquiry into the nature and life-history of these mysterious objects; and the fact that Dr. Steavenson has recognised the need of still keeping watch over them, and has carried out this piece of work with such persistence and success will, I am sure, be regarded by the Society as one excellent ground for the award of this Medal.

As we all know there are very many other departments of observational work in which Dr. Steavenson has achieved success, but I have no time to describe them. His observations of comets, the moon, planets, satellites, eclipses, and so forth come at once to mind, and they are all marked by the same enthusiasm and thoroughness as his work on the Herschel instruments, variable stars, and novæ. Indeed it has been remarked to me that his versatility and readiness, in his freedom from the bondage of any particular routine work, to turn at once, like Barnard,

to any and every phenomenon of special interest which may present itself, constitute one of his chief claims to the Society's recognition.

Dr. Steavenson, I now ask you to accept this Medal and accompanying Gift awarded to you by the Council. You have, we all hope, very many years before you, and we give you our heartiest good wishes for continued success in your work.

When in the year 1861 Mrs. Hannah Jackson (*née* Gwilt) announced her desire to present to the Society as a reversionary gift £300 new 3 per cent. stock, she expressed the wish that the dividends from the same might be expended at appropriate intervals in gifts to such persons as had accomplished some work of notable value for the advancement of astronomy; and, although the nature of the work was not restricted but left quite general, it seems that she had particularly in mind such things as the writing of a book, the invention of a new astronomical instrument, and the discovery of a new heavenly body. Mrs. Jackson died in 1893 December, and it was appropriate that when the first award was made in 1897 the recipient should be that well-known discoverer of comets—Lewis Swift. This year the Council has again awarded a Jackson-Gwilt medal and gift for cometary discoveries, viz. to Mr. William Reid of Rondebosch, C.P., South Africa, who, appropriately enough in view of his later achievements, was " born under the rays of the great comet of 1861."

Mr. Reid's actual discoveries number no less than six. In addition, he independently found Comet 1922 I (Grigg-Skjellerup) on the same night as Skjellerup, but being an hour or two later than the latter, he wished that his name should not be coupled with the comet. He had also picked up Encke's comet in 1921 on the same night as Skjellerup. Again in 1923 he found what he at first thought to be a new comet, but it turned out to be d'Arrest's. This was a particularly valuable observation, for a search had been made for this comet, which has a period of about six and a half years, and already abandoned in consequence of failure to detect it. As there was a danger at this time of the comet becoming lost, Mr. Reid's unexpected recovery of it was a most fortunate event.

Of the six new comets of which he is actually the discoverer, the first was 1918 II. It was just a round nebulous object revolving in a parabolic orbit. His second comet was 1921 II. At perihelion it was nearly as bright as the 5th magnitude, and about a week earlier a tail 40′ long had been photographed at Heidelberg. This comet passed within $4\frac{1}{2}^{\circ}$ of the North Pole, and was under observation for eight months. Mr. Reid's third discovery (1921 V) was made in 1922 January, but the comet had passed perihelion in the previous October. I will refer again to this comet in a few moments. His fourth comet was 1924 I, discovered on March 30 of that year. During the time it was brightest it was invisible in Europe, but it was well observed in the southern hemisphere during six and a half months.

The year 1925 has been justly described by Dr. Crommelin as the *annus mirabilis* for comets, since it brought no less than eleven discoveries. Also we now know that eleven comets passed perihelion

in that year. Of course—as was only right and fitting—Mr. Reid had a share in the cometary discoveries of this wonderful year, finding 1925 *b* on March 20. It was in perihelion four months later, and was altogether under observation for nearly two years. When brightest it approached naked-eye visibility. Mr. Merfield computed its orbit and found it elliptical, the period assigned being 6910 years.

Mr. Reid's sixth comet, 1926 VII, had already passed perihelion when he discovered it on 1927 January 21, and observations of it were confined to the southern hemisphere.

It will be agreed by Fellows that this record of discoveries is an exceedingly fine one. Comets are not as a rule easy prey. There is, of course, always the possibility that a casual sweep with a telescope may bring a comet into the field of view—we remember that that remarkable object, Comet 1892 III, was discovered by the late Mr. Edwin Holmes when he was not looking for comets at all—but generally speaking such objects are captured only after a very great deal of persistent and patient searching. By his tale of discoveries, then, Mr. Reid has brought much glory to observational astronomy in South Africa. I may mention, by way of contrast, that in this country only four comets have been discovered in the last three-quarters of a century. No doubt the cloudiness of our skies is partly responsible for this, for although the atmosphere can be and, more often than is commonly imagined, is as transparent here as in any other part of the world—we recall Caroline Herschel's discoveries in the latter part of the eighteenth century—yet, in view of the large amount of time which must be devoted to sweeping if there is to be any probability of success, British observers in general prefer to devote such opportunities as they have to departments of work in which there is greater certainty of securing results. Nevertheless it is, I think, something of a reproach to northern observers in general that Comet 1921 V at about the time of its perihelion passage, when it was probably a good deal brighter than some months later, should have been favourably placed for observation by us, and yet have completely eluded detection until, after passing into the southern skies, it was captured by the alert and vigilant Mr. Reid.

Of course it is not everyone—even though skilful in other ways—who can become a good observer, and certainly special qualifications are needed to make a successful comet seeker. I have already hinted at the necessity for patience and perseverance; but the observer must also have a sensitive eye and the power of quick discrimination, as various objects flit across the field of his telescope. It is very easy to sweep over and miss so delicate an object as a faint comet. Mr. Reid has remarked that his eye has become so sensitive to comets, that he has sometimes picked them up in his sweeps when his friends could not see them even though placed for them in the middle of the telescopic field.

Mr. Reid's work has, of course, gained for him a position of honour among observers, and he has occupied the Presidential Chair of the Astronomical Society of South Africa. I am sure the Fellows of this Society will enthusiastically endorse the action of their Council in this award on which I am now speaking. They will be interested, too, to hear

that a few days ago I received a letter from H.M. Astronomer at the Cape, written with special reference to this award on the day on which the announcement of it appeared in the *Cape Times*, expressing his great pleasure at the Council's action. He also remarked that in addition to his own discoveries, Mr. Reid shared indirectly in other discoveries made in South Africa by reason of the personal encouragement and help he had given to those undertaking the work of comet seeking. I am sure, too, that all will deeply regret to hear that Mr. Reid is now seriously ill and in considerable pain, but glad to know from Dr. Spencer Jones' letter that "the news of the award has cheered him up immensely."

Dr. Jackson, in handing you this medal and the accompanying gift for transmission to Mr. Reid, I will ask you to express to him our great admiration of his work, and our sincere good wishes for his recovery and restoration to health.

Election of Officers and Council.

The following Fellows were elected as Officers and Council for the ensuing year :—

President.

Rev. T. E. R. Phillips, M.A.

Vice-Presidents.

A. S. Eddington, Esq., M.A., D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy, Cambridge.
Alfred Fowler, Esq., D.Sc., F.R.S., Yarrow Research Professor of the Royal Society, Imperial College of Science and Technology, South Kensington.
J. W. L. Glaisher, Esq., Sc.D., F.R.S.
Lieut.-Col. F. J. M. Stratton, D.S.O., M.A.

Treasurer.

E. B. Knobel, Esq., D.Sc.

Secretaries.

John Jackson, Esq., M.A., D.Sc.
H. Knox-Shaw, Esq., M.A., D.Sc., Radcliffe Observer, Oxford.

Foreign Secretary.

H. H. Turner, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.

Council.

S. Chapman, Esq., M.A., D.Sc., F.R.S., Chief Professor of Mathematics, Imperial College of Science and Technology, South Kensington.
A. C. D. Crommelin, Esq., B.A., D.Sc.
C. R. Davidson, Esq.
Herbert Dingle, Esq., B.Sc., Assistant Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.
Sir Frank Dyson, K.B.E., M.A., LL.D., F.R.S., Astronomer Royal.
W. M. H. Greaves, Esq., M.A.
Major W. J. S. Lockyer, M.A., Ph.D.
Gerald Merton, Esq., M.C., M.A., Ph.D.
E. A. Milne, Esq., M.A., F.R.S., Beyer Professor of Applied Mathematics, University of Manchester.
H. F. Newall, Esq., M.A., D.Sc., F.R.S., Professor of Astrophysics, Cambridge.
W. M. Smart, Esq., M.A., D.Sc.
W. H. Steavenson, Esq.